Chapter 8

Energy

8.1 Introduction

This chapter describes the hydroelectric generation facilities and power demands for the Central Valley Project (CVP) and State Water Project (SWP) related to changes that could occur as a result of implementing the alternatives evaluated in this Environmental Impact Statement (EIS). Implementation of the alternatives could affect CVP and SWP power generation and energy demands through potential changes in operation of the CVP and SWP facilities.

Changes in CVP and SWP operations are described in more detail in Chapter 5, Surface Water Resources and Water Supplies.

8.2 Regulatory Environment and Compliance Requirements

Potential actions that could be implemented under the alternatives evaluated in this EIS could affect CVP and/or SWP hydroelectric generation and electricity use. The changes in power production and energy use would need to be compliant with appropriate Federal and state agency policies and regulations, as summarized in Chapter 4, Approach to Environmental Analysis.

8.3 Affected Environment

This section describes CVP and SWP hydroelectric generation and electricity use of the generated electricity within the study area.

The study area includes CVP and SWP hydroelectric generation facilities at the CVP and SWP reservoirs; transmission of the generated electricity; and the CVP and SWP facilities and other users throughout California that rely upon electricity generated by the CVP and SWP hydroelectric facilities. These CVP and SWP energy generation facilities are located in the Trinity River and Central Valley regions. CVP and SWP energy use primarily occurs in the Central Valley, San Francisco Bay Area, Central Coast, and Southern California regions, as defined below.

8.3.1 Central Valley Project and State Water Project Electric Generation Facilities

Hydroelectric facilities are located at most of the CVP and SWP dams, as shown on Figure 8.1. As water is released from the CVP and SWP reservoirs, the generation facilities produce power that is used by the CVP and SWP pumping plants, respectively. The SWP also generates hydroelectricity along the

California Aqueduct at energy recovery plants (California Department of Water Resources [DWR] 2013a, 2013b). Between 1983 and 2013, the DWR owned a portion of the Nevada Power Company's coal-fired Reid Gardner Unit 4 Powerplant. However, this agreement was not renewed upon expiration in 2013.

Power generated by the CVP is transmitted by Western Area Power Administration (Western) to CVP facilities. Power that is excess to CVP needs is marketed by Western to electric utilities, government and public installations, and commercial "preference" customers who have 20-year contracts (Bureau of Reclamation [Reclamation] 2012a). Power generated by the SWP is transmitted by Pacific Gas & Electric Company, Southern California Edison, and California Independent System Operator through other facilities (DWR 2013a, 2013b). The SWP also markets energy in excess of the SWP demands to a utility and members of the Western Systems Power Pool.

Hydropower is an important renewable energy and supplies between 14 and 28 percent of electricity used in California depending upon the water year type (The California Energy Commission [CEC] 2014a; Hydropower Working Group [HWG] 2014). In 1992, at the end of the 1987-to-1992 drought, hydropower provided less than 11 percent of the electricity used in California. However, during a wetter year (1995), hydropower provided approximately 28 percent of electricity used in California. Between 1982 and 2012, approximately 33,927 gigawatt-hours were generated in California by hydropower, including approximately 4,810 and 2,613 gigawatt-hours generated by the CVP and SWP, respectively.

8.3.1.1 CVP Hydroelectric Generation Facilities

The CVP power facilities include 11 hydroelectric powerplants and have a total maximum generating capacity of 2,076 megawatts, as presented in Table 8.1. Hydrology can vary significantly from year to year, which then affects the hydropower production. Typically, in an average water year, approximately 4,500 gigawatt-hours of energy is produced (Reclamation 2012a). Major factors that influence powerplant operations include required downstream water releases, electric system needs, and project use demand. The power generated from CVP powerplants is dedicated to first meeting the requirements of the CVP facilities. The remaining energy is marketed by Western to preferred customers in northern California.

Table 8.1 Central Valley Project Hydroelectric Powerplants

Facility	Installed Capacity (Megawatts)
Trinity Powerplant	140
Lewiston Powerplant	0.35
Judge Francis Powerplant	154
Shasta Powerplant	710
Spring Creek Powerplant	180
Keswick Powerplant	117
Folsom Powerplant	207
Nimbus Powerplant	17
New Melones Powerplant	383
O’Neill Pump-Generating Plant	14.4
San Luis Powerplant (CVP portion of the William R. Gianelli/San Luis Pump-Generating Plant)	202

Sources: Reclamation 2013a, 2013b, 2013c, 2013d, 2013e, 2013f, 2013g, 2013h, 2013i, 2013j, 2013k, 2013l

8.3.1.1.1 Trinity Division Powerplants

The Trinity Powerplant is located along the Trinity River (Reclamation 2013b). Primary releases of Trinity Dam are made through the powerplant. Trinity County has first preference to the power from this plant.

The Lewiston Powerplant is located at the Lewiston Dam along the Trinity River (Reclamation 2013c). It is operated in conjunction with the spillway gates to maintain the minimum flow in the Trinity River downstream. The turbines are usually set at maximum output with the spillway gates adjusted to regulate river flow. The turbine capacity is less than the Trinity River minimum flow criteria, as described in Chapter 5, Surface Water Resources and Water Supplies. The Lewiston Powerplant provides power to the adjacent fish hatchery.

The Judge Francis Carr Powerplant is a peaking powerplant located on the Clear Creek Tunnel (Reclamation 2013d). It generates power from water exported from the Trinity River Basin. Similar to Trinity Powerplant, Trinity County has first preference to the power benefit from this facility.

8.3.1.1.2 Sacramento River Powerplants

The Shasta Powerplant is a peaking powerplant located downstream of Shasta Dam along the Sacramento River (Reclamation 2013a, 2013e). Until early 1990s, concerns with downstream temperatures resulted in the bypasses of outflows around the powerplant and lost hydropower generation. Installation of the Shasta Temperature Control Device enabled operators to decide the depth of the reservoir from which the water feeding into the penstocks originates. The system has shown significant success in controlling the water temperature of powerplant releases through Shasta Dam. The Shasta Powerplant also provides water supply for the Livingston Stone National Fish Hatchery.

The Spring Creek Powerplant is a peaking plant located along Spring Creek, at the foot of Spring Creek Debris Dam (Reclamation 2013f). Water discharged via the Judge Francis Carr Powerplant flows into the Whiskeytown Reservoir and then provides the source of water for the Spring Creek Powerplant generation. Trinity County has first preference to the power benefits from Spring Creek Powerplant. Water from Spring Creek Powerplant is discharged into Keswick Reservoir. Releases from Spring Creek Powerplant also are operated to maintain water quality in the Spring Creek arm of Keswick Reservoir.

The Keswick Powerplant is located at Keswick Dam along the Sacramento River downstream of Shasta Dam and regulates the flows into the Sacramento River from both Shasta Lake and Spring Creek releases and can be considered as a run-of-the-river powerplant (Reclamation 2013g).

8.3.1.1.3 American River Powerplants

The Folsom Powerplant is a peaking powerplant located at Folsom Dam along the American River (Reclamation 2013h). The Folsom Powerplant is operated in an integrated manner with flood control operations at Folsom Lake. One of the integrated operations is related to coordinating early flood control releases with power generation. It also provides power for the pumping plant that supplies the local domestic water supply. Folsom Powerplant supports voltage support for the Sacramento Region during summer heavy load times.

The Nimbus Powerplant is located at Nimbus Dam along the American River, downstream of Folsom Dam (Reclamation 2013i). The Nimbus Powerplant regulates releases from Folsom Dam into the American River and can be considered as a run-of-the river powerplant.

8.3.1.1.4 Stanislaus River Powerplants

The New Melones Powerplant is a peaking powerplant located along the Stanislaus River (Reclamation 2013j). Primary reservoir releases are made through the powerplant. This plant provides significant voltage support to the Pacific Gas and Electric Company system during summer heavy load periods.

8.3.1.1.5 San Luis Reservoir Powerplants

The O’Neill Pump-Generating Plant is located on a channel that conveys water between the Delta-Mendota Canal and the O’Neill Forebay (Reclamation 2013k). This pump-generating plant only generates power when water is released from the O’Neill Reservoir to the Delta-Mendota Canal. When water is conveyed from the Delta-Mendota Canal to O’Neill Forebay, the units serve as pumps, not hydroelectric generators. The generated power is used to support CVP pumping and irrigation actions of the CVP.

The William R. Gianelli (San Luis) Pump-Generating Plant is located along the along the western boundary of the O’Neill Forebay at the San Luis Dam

(Reclamation 2013l). This pump-generating plant is owned by the Federal government but is operated as a joint Federal-State facility that is shared by the CVP and SWP. Energy is generated when water is needed to be conveyed from San Luis Reservoir back into O'Neill Forebay for continued conveyance to the Delta-Mendota Canal. The plant is operated in pumping mode when water is moved from O'Neill Forebay to San Luis Reservoir for storage until heavier water demands develop. The generated power is used to offset CVP and SWP pumping loads. The powerplant can generate up to 424 megawatts, with the CVP share of the total capacity being 202 megawatts. This facility is operated and maintained by the State of California under an operation and maintenance agreement with Reclamation.

8.3.1.2 SWP Electric Generation Facilities

The SWP power facilities are operated primarily to provide power for the SWP facilities (DWR 2013b). The SWP power facilities and capacities are summarized in Table 8.2. The SWP has power contracts with electric utilities and the California Independent System Operator that act as exchange agreements with utility companies for transmission and power sales/purchases. In all years, the SWP must purchase additional power to meet pumping requirements.

Table 8.2 State Water Project Hydroelectric Powerplants

Facility	Installed Capacity (Megawatts)
Oroville Facilities	–
Hyatt Pumping-Generating Plant	645
Thermalito Diversion Dam Powerplant	3
Thermalito Pumping-Generating Plant	114
William R. Gianelli (San Luis) Pumping-Generating Plant (SWP share)	222
Alamo Powerplant	17
Mojave Siphon Powerplant	30
Devil Canyon Powerplant	276
Warne Powerplant	74

Source: DWR 2012

8.3.1.2.1 Feather River Powerplants

The Hyatt Pumping-Generating Plant is located on the channel between Lake Oroville and the Thermalito Diversion Pool (DWR 2007). Water in the Thermalito Diversion Pool can be pumped back to Lake Oroville to be released through the Hyatt Pumping-Generating Plant and generate more electricity; released through the Thermalito Diversion Dam Powerplant for delivery to the low flow channel upstream of Thermalito Forebay; or conveyed to Thermalito Forebay for subsequent release through the Thermalito Pumping-Generating Plant. The combined Hyatt Pumping-Generating Plant and Thermalito Pumping-Generating Plant generate approximately 2,200 gigawatt-hours of energy in a median water year, while the 3 megawatts generated by Thermalito Diversion Dam Powerplant adds another 24 gigawatt-hours per year (DWR 2013).

8.3.1.2.2 San Luis Reservoir Powerplant

As described above, the William R. Gianelli (San Luis) Pump-Generating Plant is owned by the Federal government and is operated as a joint Federal-state facility that is shared by the CVP and SWP. The SWP water flows from the California Aqueduct into O'Neill Forebay downstream of the CVP's O'Neill Pump-Generating Plant. The pump-generating plant is located along the western boundary of the O'Neill Forebay at the San Luis Dam (DWR 2013a, 2013b, Reclamation 2013l). Electricity is generated when water is transferred from San Luis Reservoir back to O'Neill Forebay for continued conveyance in the California Aqueduct. The plant acts as a pumping plant when water is transferred from O'Neill Forebay to San Luis Reservoir. The generated power is used to offset CVP and SWP pumping loads. The powerplant can generate up to 424 megawatts, with the SWP share of the total capacity being 222 megawatts. This facility is operated and maintained by the State of California under an operation and maintenance agreement with Reclamation.

8.3.1.2.3 East Branch and West Branch Powerplants

Downstream of the Antelope Valley, the California Aqueduct divides into the East Branch and West Branch. The Alamo Powerplant, Mojave Powerplant, and Devil Canyon Powerplant are located along the East Branch which conveys water into San Bernardino County (DWR 2013a, 2013b). The Warne Powerplant is located along the West Branch which conveys water into Los Angeles County. The generation rates vary at these powerplants depending upon the amount of water conveyed.

8.3.1.2.4 Other Energy Resources for the State Water Project

Other energy supplies have been obtained by DWR from other utilities and energy marketers under agreements that allow DWR to buy, sell, or exchange energy on a short-term hourly basis or a long-term multi-year basis (DWR 2013a, 2013b).

For example, DWR jointly developed the 1,254-megawatt Castaic Powerplant on the West Branch with the Los Angeles Department of Water and Power (DWR 2012, 2013). The power is available to DWR at the Sylmar Substation.

DWR has a long-term purchase agreement with the Kings River Conservation District for the approximately 400 million kilowatt-hours of energy from the 165-megawatt hydroelectric Pine Flat Powerplant (DWR 2012, 2013). DWR also purchases energy from five hydroelectric plants with 30 megawatts of installed capacity that are owned and operated by Metropolitan Water District of Southern California (DWR 2012, 2013).

DWR also purchases energy under short-term purchase agreements from utilities and energy marketers of the Western Systems Power Pool (DWR 2012, 2013). In addition, the 1988 Coordination Agreement between DWR and Metropolitan

Water District of Southern Californian enables DWR to purchase and exchange energy (DWR 2012, 2013).

8.3.2 Other Hydroelectric Generation Facilities

Hydroelectric facilities in addition to CVP and SWP hydroelectric facilities in the study area are owned by investor-owned utility companies, such as Pacific Gas & Electric Company and Southern California Edison; municipal agencies, such as Sacramento Municipal Utility District; and by local and regional water agencies. Some of the larger facilities outside the CVP and SWP systems and within or adjacent to the study area include (DWR 2013d; 2013e; YCWA 2012):

- Pacific Gas and Electric Company
  - Helms Pumped Storage (1,200 megawatts) in Fresno County.
  - Pit System (320 megawatts) and McCloud-Pit System (370 megawatts, total) in Shasta County.
  - Upper North Fork Feather River System (360 megawatts) in Plumas County.
- Sacramento Municipal Utility District Upper American River Project System (688 megawatts) in El Dorado County.
- City and County of San Francisco Hetch Hetchy Power System (390 megawatts) in Tuolumne County.
- Southern California Edison
  - Big Creek System and Eastwood Pump Storage (approximately 1,000 megawatts) in Fresno and Madera counties.
  - Mammoth Pool Project (187 megawatts) in Fresno and Madera counties.
- Turlock Irrigation District and Modesto Irrigation District New Don Pedro Project (203 megawatts) in Tuolumne County.
- Yuba County Water Agency Yuba River Development Project (390 megawatts) in Yuba County.

8.3.3 CVP and SWP System Energy Demands

Power generation at CVP and SWP hydropower facilities fluctuates in response to reservoir releases and conveyance flows. Reservoir releases are significantly affected by hydrologic conditions, minimum stream flow requirements, flow fluctuation restrictions, water quality requirements, and non-CVP and non-SWP water rights which must be met prior to releases for CVP water service contractors and SWP entitlement holders.

8.3.3.1 CVP Power Generation and Energy Use

The CVP power generation facilities were developed to meet CVP energy use loads.

The majority of the energy used by the CVP is needed for pumping plants located in the Delta, at San Luis Reservoir, and along the Delta-Mendota Canal and San Luis Canal portion of the California Aqueduct. Table 8.3 presents historical average annual CVP hydropower generation and use. Monthly power generation pattern follows seasonal reservoir releases, with peaks during the irrigation season, as shown on Figure 8.2. The hydropower generation between January and June decreases after 2007 because the potential to convey CVP water across the Delta during this period was reduced after 2007 to reduce reverse flows in Old and Middle River, in accordance with legal decisions and subsequently through implementation of the biological opinions.

Table 8.3 Hydropower Generation and Energy Use by the CVP

Calendar Year	Water Year Type[a]	Net CVP Hydropower Generation (Gigawatt-hours)	Energy Used CVP Facilities (Gigawatt-hours)
2000	AN	5,667	–
2001	D	4,107	957
2002	D	4,322	1,090
2003	AN	5,483	1,170
2004	BN	5,186	1,172
2005	AN	4,599	1,150
2006	W	7,284	1,037
2007	D	4,276	1,064
2008	C	3,659	923
2009	D	3,560	803
2010	BN	3,624	1,001
2011	W	5,469	1,276
2012	BN	4,849	990

Sources: Reclamation 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008a-l, 2009a-l, 2010a-l, 2011a-l, 2012b-m.

Note:
a. Water Year Type based on Sacramento Valley 40-30-30 Index, as described in Chapter 5, Surface Water Resources and Water Supplies.

Recently, the California Public Utilities Commission (CPUC) evaluated the “energy intensity” of several types of water supplies (CPUC 2010). The energy intensity is defined as the average amount of energy required to convey and/or treat water on a unit basis, such as per 1 acre-foot. Substantial quantities of energy are required by the CVP pumping plants to convey large amounts of water over long distances with significant changes in elevation. The study indicated that the energy intensity of CVP water delivered to users downstream of San Luis Reservoir ranged from 0.292 megawatt-hours/acre-foot for users along the Delta-Mendota Canal; to 0.428 megawatt-hours/acre-foot for users along the San Luis

Canal/California Aqueduct; to 0.870 megawatt-hours/acre-foot in San Benito and Santa Clara counties.

8.3.3.2 SWP Power Generation and Energy Use

The SWP power generation facilities also were developed to meet SWP energy use loads. The majority of the energy used by the SWP is needed for pumping plants located in the Delta, at the San Luis Reservoir, and along the California Aqueduct. Table 8.4 presents historical average annual SWP hydropower generation and use. Monthly power generation pattern follows seasonal reservoir releases, with peaks during the irrigation season, as shown on Figure 8.3.

Table 8.4 presents SWP power use and generation values for the period 2001 through 2012 that indicate the SWP generates approximately 63 percent of the energy needed for deliveries (DWR 2002, 2004a, 2004b, 2005, 2006, 2007, 2008, 2012a, 2012b, 2013). The energy generation and purchases and energy use decreases after 2007 because the potential to convey SWP water across the Delta was reduced in accordance with legal decisions and subsequently through implementation of the biological opinions.

Table 8.4 Hydropower Generation and Energy Use by the State Water Project

Calendar Year	Water Year Type[a]	SWP Hydropower Generation (Gigawatt-hour)	Energy Acquired through Long-term Agreements and Purchases (Gigawatt-hour)	Energy Used by SWP Facilities (Gigawatt-hour)
2000	AN	6,372	5,741	9,190
2001	D	4,295	4,660	6,656
2002	D	4,953	4,610	8,394
2003	AN	5,511	4,668	9,175
2004	BN	6,056	4,429	9,868
2005	AN	5,151	5,367	8,308
2006	W	7,056	5,811	9,158
2007	D	5,577	6,642	9,773
2008	C	3,541	4,603	5,745
2009	D	4,295	4,660	6,656
2010	BN	4,953	4,610	8,394
2011	W	5.511	4,668	9.175
2012	BN	6,056	4,429	9.868

Sources: DWR 2002, 2004a, 2004b, 2005, 2006, 2007, 2008, 2012a, 2012b, 2013

Note:

a. Water Year Type based on Sacramento Valley 40-30-30 Index, as described in Chapter 5, Surface Water Resources and Water Supplies.

The energy intensity values calculated by the California Public Utilities Commission for the SWP ranged from 1.128 megawatt-hours/acre-foot for water users along the South Bay Aqueduct; to 1.157 megawatt-hours/acre-foot for water users in Kern County; to 4,644 megawatt-hours/acre-foot for water users at the terminal end of the East Branch Extension of the California Aqueduct (CPUC 2010).

8.3.4 Energy Demands for Groundwater Pumping

Groundwater provided approximately 37 percent of the state's agricultural, municipal, and industrial water supply of the average water needs between 1998 and 2010, or approximately 16 million acre-feet/year of groundwater (DWR 2013). The use of groundwater varies regionally throughout the State. For example in some areas, groundwater provides less than 10 percent to more than 90 percent, as described in Chapter 7, Groundwater Resources and Groundwater Quality.

The amount of energy used statewide to pump groundwater is not well quantified (CPUC 2010). The California Public Utilities Commission estimated groundwater energy use by hydrologic region and by type of use to evaluate the water and energy relationships. Groundwater pumping estimates were calculated in each DWR Planning Areas for agricultural and municipal water demands. Groundwater energy use was estimated based upon assumptions of well depths and pump efficiencies. Some wells use natural gas for individual engines instead of electricity; however, the amount of natural gas pumping versus electric pumping is generally unknown. In 2010, average groundwater use in the state was approximately 14.7 million acre-feet, or 36 percent of total agricultural, municipal, and industrial water supplies (DWR 2013). The California Public Utilities Commission estimated that in 2010, statewide groundwater pumping accounted for more electricity use between May and August than the total electricity use by the CVP and SWP during that time period (CPUC 2010). Over the entire year, it was estimated that groundwater pumping used approximately 10 percent more electricity than the SWP and approximately 5 percent less than the CVP and SWP combined.

8.4 Impact Analysis

This section describes the potential mechanisms for change in energy generation and analytical methods; results of the impact analyses; potential mitigation measures; and cumulative effects.

8.4.1 Potential Mechanisms for Change and Analytical Tools

The environmental consequences assessment considers changes in energy resources conditions related to changes in CVP and SWP operations under the alternatives as compared to the No Action Alternative and Second Basis of Comparison.

8.4.1.1 Changes in Energy Resources Related to CVP and SWP Water Users

Energy generation is limited on a monthly bases by the average power capacity of each generation facility based upon reservoir elevations and water release patterns. The majority of the CVP and SWP energy use is for the conveyance facilities located in the Delta and south of the Delta. Energy use would change with changes in CVP and SWP deliveries.

Reservoir elevations and flow patterns through pumping facilities output from the CalSim II model (see Chapter 5, Surface Water Resources and Water Supplies) are used with LTGen and SWP Power tools, as described in Appendix 8A, Power Model Documentation. These tools estimate average annual peaking power capacity, energy use, and energy generation at CVP and SWP facilities, respectively. The tools estimate average annual energy generation and use and net generation. When net generation values are negative, the CVP or SWP would purchase power from other generation facilities. When net generation values are positive, power would be available for use by non-CVP and SWP electricity users.

When CVP and SWP water deliveries change, water users would are anticipated do change their use of groundwater, recycled water, and/or desalinated water, as described in Chapter 5, Surface Water Resources and Water Supplies, Chapter 12, Agricultural Resources, and Chapter 19, Socioeconomics. Specific responses by water users to changes in CVP and SWP water deliveries are not known; and therefore, energy use for the alternate water supplies cannot be quantified in this analysis. It is not known whether the net change in energy use for the CVP and SWP would or would not be similar to the net change in energy use for alternate water supplies (e.g., groundwater pumping, water treatment, water conveyance).

8.4.1.2 Effect Related to Cross Delta 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. Water transfers using CVP and SWP Delta pumping plants and south of Delta canals generally occur when there is unused capacity in these facilities, especially in drier 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.

Changes in net energy generation could occur statewide during cross Delta water transfers due to following reasons:

- Changed reservoir release patterns at CVP and SWP reservoirs
- Changed conveyance patterns at the CVP and SWP pumping plants

- Increased groundwater pumping in the seller's service area if groundwater substitution is used to make the transferred water available
- Reductions in groundwater pumping in the purchaser's service area if less groundwater would be used due to the water transfer

Reclamation recently prepared a long-term regional water transfer environmental document which evaluated potential changes in surface water 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.

8.4.2 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. Other future conditions would be different under the No Action Alternative as compared to the Second Basis of Comparison due to the implementation of the 2008 U.S. Fish and Wildlife Service (USFWS) Biological Opinion (BO) and 2009 National Marine Fisheries Service (NMFS) BO under the No Action Alternative.

This section of Chapter 8 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 USFWS BO and 2009 NMFS BO; and consider changes that would have occurred without implementation of the 2008 USFWS BO and the 2009 NMFS BO.

8.4.2.1 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.

8.4.2.1.1 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 potential hydropower generation in the summer. These conditions would occur for all reservoirs in the California foothills and mountains, including non-CVP and SWP reservoirs.

8.4.2.1.2 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. 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.

Statewide the increased population would result in increased energy demands. Under the No Action Alternative and Second Basis of Comparison, it is assumed that energy demands would be met on a long-term basis and in dry and critical dry years using a combination of conservation, increased efficiency in energy generation and transmission, and renewable energy sources.

8.4.2.1.3 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 involve additional water treatment and conveyance facilities that would change statewide energy demands.

8.4.2.2 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 energy generation would be less in the summer months when energy demand is high for water conveyance and air conditioning equipment throughout the state. It is also anticipated that water deliveries would be less in 2030 than under recent historical conditions; and, therefore, energy use for CVP and SWP water conveyance facilities would be less.

8.4.2.3 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 energy generation would be less in the summer months when energy demand is high for water conveyance and air conditioning equipment throughout the State. It is also anticipated that water deliveries would be less in 2030 than under recent historical conditions; and, therefore, energy use for CVP and SWP water conveyance facilities would be less.

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. Therefore, CVP and SWP energy use would be greater, and possibly groundwater pumping use would be less, under the Second Basis of Comparison as compared to the No Action Alternative.

8.4.3 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

8.4.3.1 No Action Alternative

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

8.4.3.1.1 Potential Changes in Energy Resources Related to CVP and SWP Water Users

Changes in CVP and SWP operations under the No Action Alternative as compared to the Second Basis of Comparison would result in a reduction of CVP and SWP water deliveries to areas located south of the Delta; and therefore, annual energy use would result in changes in CVP and SWP energy resources, as summarized in Table 8.5. The CVP net generation over the long-term conditions (averaged over the 81-year model simulation period, as described in Chapter 5) and in dry and critical dry years would be similar (within 5 percent) under the No Action Alternative and the Second Basis of Comparison. The SWP net generation would be reduced by 29 percent over the long-term condition and by 37 percent in dry and critical dry years. Changes in monthly energy use are presented in Appendix 8A, Power Model Documentation.

Table 8.5 Energy Generation, Energy Use, and Net Generation under the No Action Alternative as Compared to the Second Basis of Comparison

Project	Water Year	Energy (Gigawatt-hours)	No Action Alternative (NAA)	Second Basis of Comparison (SBC)	Changes between NAA and SBC
CVP Facilities	Long-term Average	Energy Generation	4,558	4,604	-46
		Energy Use	1,113	1,289	-177
		Net Generation	3,445	3,315	131
	Dry and Critical Water Years	Energy Generation	2,696	2,773	-77
		Energy Use	699	773	-75
		Net Generation	1,997	2,000	-2
SWP Facilities	Long-term Average	Energy Generation	4,202	4,721	-520
		Energy Use	7,798	9,802	-2,004
		Net Generation	-3,597	-5,081	1,484
	Dry and Critical Water Years	Energy Generation	1,914	2,494	-579
		Energy Use	3,929	5,686	-1,757
		Net Generation	-2,015	-3,192	1,177

Under the No Action Alternative as compared to the Second Basis of Comparison, CVP and SWP water deliveries would be less and it is anticipated that CVP and SWP water users would use more alternate water supplies. These alternate water supplies would require energy. Specific changes in energy use would depend upon specific responses by water users, and are not known at this time. Therefore, it is uncertain whether the increased regional and local water supply energy requirements would be similar to the reduced energy use by the CVP and SWP operations in 2030 under the No Action Alternative as compared to the Second Basis of Comparison. For the purposes of this analysis, a worse-case scenario is assumed, and that total energy use by CVP and SWP water users could be higher under the No Action Alternative than under the Second Basis of Comparison.

8.4.3.1.2 Effects Related to Cross Delta Water Transfers

Potential effects to energy 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 energy resources were identified as changes in power generation patterns at the reservoirs due to changes in reservoir release patterns and surface water elevation patterns. These potential changes were not considered to be substantial because the total amount of electricity generated would be similar and the power loss would be minimal due to changes in release patterns. 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 pumping 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 pumping 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; however, energy resources conditions would be similar.

8.4.3.2 Alternative 1

Alternative 1 is identical to the Second Basis of Comparison. Alternative 1 is compared to the No Action Alternative and the Second Basis of Comparison. However, because energy resource conditions under Alternative 1 are identical to energy resource conditions under the Second Basis of Comparison; Alternative 1 is only compared to the No Action Alternative.

8.4.3.2.1 Alternative 1 Compared to the No Action Alternative

Potential Changes in Energy Resources Related to CVP and SWP Water Users

Changes in CVP and SWP operations under Alternative 1 as compared to the No Action Alternative would result in an increase of CVP and SWP water deliveries to areas located south of the Delta; and therefore, annual energy use would result in changes in CVP and SWP energy resources, as summarized in Table 8.6. The CVP net generation over the long-term conditions and in dry and critical dry years would be similar under Alternative 1 as compared to the No Action Alternative. The SWP net generation would be increased by 41 percent over the long-term condition and by 58 percent in dry and critical dry years. Changes in monthly energy use are presented in Appendix 8A, Power Model Documentation.

Table 8.6 Energy Generation, Energy Use, and Net Generation under Alternative 1 as Compared to the No Action Alternative

Project	Water Year	Energy (Gigawatt-hours)	Alternative 1	No Action Alternative (NAA)	Changes between Alternative 1 and NAA
CVP Facilities	Long-term Average	Energy Generation	4,604	4,558	46
		Energy Use	1,289	1,113	177
		Net Generation	3,315	3,445	-131
	Dry and Critical Water Years	Energy Generation	2,773	2,696	77
		Energy Use	773	699	75
		Net Generation	2,000	1,997	2
SWP Facilities	Long-term Average	Energy Generation	4,721	4,202	520
		Energy Use	9,802	7,798	2,004
		Net Generation	-5,081	-3,597	-1,484
	Dry and Critical Water Years	Energy Generation	2,494	1,914	579
		Energy Use	5,686	3,929	1,757
		Net Generation	-3,192	-2,015	-1,177

Under Alternative 1 as compared to the No Action Alternative, CVP and SWP water deliveries would be increased and it is anticipated that CVP and SWP water users would use less alternate water supplies. Specific changes in energy use would depend upon specific responses by water users, and are not known at this time. Therefore, it is uncertain whether the decreased regional and local water supply energy requirements would be similar to the increased energy use by the CVP and SWP operations in 2030 under Alternative 1 as compared to the No Action Alternative. For the purposes of this analysis, a worse-case scenario is assumed, and that total energy use by CVP and SWP water users could be lower under Alternative 1 as compared to the No Action Alternative.

Effects Related to Cross Delta Water Transfers

Potential effects to energy 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 energy conditions would occur during implementation of cross Delta water transfers under Alternative 1 and the No Action Alternative.

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; however, energy resources conditions would be similar.

8.4.3.2.2 Alternative 1 Compared to the Second Basis of Comparison

Alternative 1 is identical to the Second Basis of Comparison.

8.4.3.3 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 energy resources conditions under Alternative 2 is only compared to the Second Basis of Comparison.

8.4.3.3.1 Alternative 2 Compared to the Second Basis of Comparison

Changes to energy resources under Alternatives 2 as compared to the Second Basis of Comparison would be the same as the impacts described in Section 8.4.3.1, No Action Alternative.

8.4.3.4 Alternative 3

CVP and SWP operations under Alternative 3 are similar to the Second Basis of Comparison with modified Old and Middle River flow criteria and New Melones Reservoir operations. Alternative 3 would include changed water demands for American River water supplies as compared to the No Action Alternative or

Second Basis of Comparison. Alternative 3 would provide water supplies of up to 17 TAF/year under a Warren Act Contract for El Dorado Irrigation District and 15 TAF/year under a Warren Act Contract for El Dorado County Water Agency. These demands are not included in the analysis presented in this section of the EIS. A sensitivity analysis comparing the results of the analysis with and without these demands is presented in Appendix 5B of this EIS.

8.4.3.4.1 Alternative 3 Compared to the No Action Alternative

Potential Changes in Energy Resources to CVP and SWP Water Users

Changes in CVP and SWP operations under Alternative 3 as compared to the No Action Alternative would result in changes in CVP and SWP energy resources, as summarized in Table 8.7. The CVP net generation over the long-term conditions and in dry and critical dry years would be similar under Alternative 3 as compared to the No Action Alternative. The SWP net generation would be increased by 27 percent over the long-term condition and by 16 percent in dry and critical dry years. Changes in monthly energy use are presented in Appendix 8A, Power Model Documentation.

Table 8.7 Energy Generation, Energy Use, and Net Generation under Alternative 3 as Compared to the No Action Alternative

Project	Water Year	Energy (Gigawatt-hours)	Alternative 3	No Action Alternative (NAA)	Changes between Alternative 3 and NAA
CVP Facilities	Long-term Average	Energy Generation	4,582	4,558	24
		Energy Use	1,238	1,113	125
		Net Generation	3,344	3,445	-102
	Dry and Critical Water Years	Energy Generation	2,798	2,696	102
		Energy Use	715	699	16
		Net Generation	2,084	1,997	86
SWP Facilities	Long-term Average	Energy Generation	4,537	4,202	335
		Energy Use	9,115	7,798	1,317
		Net Generation	-4,578	-3,597	-981

Project	Water Year	Energy (Gigawatt-hours)	Alternative 3	No Action Alternative (NAA)	Changes between Alternative 3 and NAA
	Dry and Critical Water Years	Energy Generation	2,128	1,914	214
		Energy Use	4,455	3,929	526
		Net Generation	-2,327	-2,015	-312

Under Alternative 3 as compared to the No Action Alternative, CVP and SWP water deliveries would be increased and it is anticipated that CVP and SWP water users would use less alternate water supplies. Specific changes in energy use would depend upon specific responses by water users, and are not known at this time. Therefore, it is uncertain whether the decreased regional and local water supply energy requirements would be similar to the increased energy use by the CVP and SWP operations in 2030 under Alternative 3 as compared to the No Action Alternative. For the purposes of this analysis, a worse-case scenario is assumed, and that total energy use by CVP and SWP water users could be lower under Alternative 3 as compared to the No Action Alternative.

Effects Related to Cross Delta Water Transfers

Potential effects to energy 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 energy conditions would occur during implementation of cross Delta water transfers under Alternative 3 and the No Action Alternative.

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; however, energy resources conditions would be similar.

8.4.3.4.2 Alternative 3 Compared to the Second Basis of Comparison

Potential Changes in Energy Resources to CVP and SWP Water Users

Changes in CVP and SWP operations under Alternative 3 as compared to the Second Basis of Comparison would result in changes in CVP and SWP energy resources, as summarized in Table 8.8. The CVP net generation over the long-term conditions and in dry and critical dry years would be similar under Alternative 3 as compared to the Second Basis of Comparison. The SWP net generation would be reduced by 10 percent over the long-term condition and by 58 percent in dry and critical dry years. Changes in monthly energy use are presented in Appendix 8A, Power Model Documentation.

Table 8.8 Energy Generation, Energy Use, and Net Generation under Alternative 3 as Compared to the Second Basis of Comparison

Project	Water Year	Energy (Gigawatt-hours)	Alternative 3	Second Basis of Comparison (SBC)	Changes between Alternative 3 and SBC
CVP Facilities	Long-term Average	Energy Generation	4,582	4,604	-22
		Energy Use	1,238	1,289	-51
		Net Generation	3,344	3,315	29
	Dry and Critical Water Years	Energy Generation	2,798	2,773	25
		Energy Use	715	773	-59
		Net Generation	2,084	2,000	84
SWP Facilities	Long-term Average	Energy Generation	4,537	4,721	-184
		Energy Use	9,115	9,802	-687
		Net Generation	-4,578	-5,081	503
	Dry and Critical Water Years	Energy Generation	2,128	2,494	-366
		Energy Use	4,455	5,686	-1,230
		Net Generation	-2,327	-3,192	865

Under Alternative 3 as compared to the Second Basis of Comparison, CVP and SWP water deliveries would be decreased and it is anticipated that CVP and SWP water users would use more alternate water supplies. Specific changes in energy use would depend upon specific responses by water users, and are not known at this time. Therefore, it is uncertain whether the increased regional and local water supply energy requirements would be similar to the decreased energy use by the CVP and SWP operations in 2030 under Alternative 3 as compared to the Second Basis of Comparison. For the purposes of this analysis, a worse-case scenario is assumed, and that total energy use by CVP and SWP water users could be higher under Alternative 3 as compared to the Second Basis of Comparison.

Effects Related to Cross Delta Water Transfers

Potential effects to energy 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 energy conditions would occur during implementation of cross Delta water transfers under Alternative 3 as compared to the Second Basis of Comparison.

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 as compared to the Second Basis of Comparison; and energy resources conditions would be similar.

8.4.3.5 Alternative 4

Energy resources under Alternative 4 would be identical to the conditions under the Second Basis of Comparison. Alternative 4 is only compared to the No Action Alternative.

8.4.3.5.1 Alternative 4 Compared to the No Action Alternative

Changes in energy resources under Alternative 4 as compared to the No Action Alternative would be the same as the impacts described in Section 8.4.3.2.1, Alternative 1 Compared to the No Action Alternative.

8.4.3.6 Alternative 5

The 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. Alternative 5 would include changed water demands for American River water supplies as compared to the No Action Alternative or Second Basis of Comparison. Alternative 5 would provide water supplies of up to 17 TAF/year under a Warren Act Contract for El Dorado Irrigation District and 15 TAF/year under a Warren Act Contract for El Dorado County Water Agency. These demands are not included in the analysis presented in this section of the EIS. A sensitivity analysis comparing the results of the analysis with and without these demands is presented in Appendix 5B of this EIS.

8.4.3.6.1 Alternative 5 Compared to the No Action Alternative

Potential Changes in Energy Resources to CVP and SWP Water Users

Changes in CVP and SWP operations under Alternative 5 as compared to the No Action Alternative would result in changes in CVP and SWP energy resources, as summarized in Table 8.9. The CVP and SWP net generation over the long-term conditions and in dry and critical dry years would be similar under Alternative 5 as compared to the No Action Alternative. Changes in monthly energy use are presented in Appendix 8A, Power Model Documentation.

Table 8.9 Energy Generation, Energy Use, and Net Generation under Alternative 5 as Compared to the No Action Alternative

Project	Water Year	Energy (Gigawatt-hours)	Alternative 3	Second Basis of Comparison (SBC)	Changes between Alternative 3 and SBC
CVP Facilities	Long-term Average	Energy Generation	4,552	4,558	-6
		Energy Use	1,110	1,113	-3
		Net Generation	3,442	3,445	-4
	Dry and Critical Water Years	Energy Generation	2,684	2,696	-12
		Energy Use	699	699	0
		Net Generation	1,986	1,997	-11
SWP Facilities	Long-term Average	Energy Generation	4,191	4,202	-11
		Energy Use	7,732	7,798	-66
		Net Generation	-3,541	-3,597	56
	Dry and Critical Water Years	Energy Generation	1,904	1,914	-10
		Energy Use	3,841	3,929	-88
		Net Generation	-1,937	-2,015	78

Under Alternative 5 as compared to the No Action Alternative, CVP and SWP water deliveries would be similar, and it is anticipated that CVP and SWP water users would use similar alternate water supplies. Therefore, for the purposes of this analysis, it is assumed that total energy use by CVP and SWP water users could be similar under Alternative 5 as compared to the No Action Alternative.

Effects Related to Cross Delta Water Transfers

Potential effects to energy 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 energy conditions would occur during implementation of cross Delta water transfers under Alternative 5 and the No Action Alternative.

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; and energy resources conditions would be similar.

8.4.3.6.2 Alternative 5 Compared to the Second Basis of Comparison

Potential Changes in Energy Resources to CVP and SWP Water Users

Changes in CVP and SWP operations under Alternative 5 as compared to the Second Basis of Comparison would result in changes in CVP and SWP energy resources, as summarized in Table 8.10. The CVP net generation over the long-term conditions and in dry and critical dry years would be similar under Alternative 3 as compared to the Second Basis of Comparison. The SWP net generation would be reduced by 30 percent over the long-term condition and by 39 percent in dry and critical dry years. Changes in monthly energy use are presented in Appendix 8A, Power Model Documentation.

Table 8.10 Energy Generation, Energy Use, and Net Generation under Alternative 5 as Compared to the Second Basis of Comparison

Project	Water Year	Energy (Gigawatt-hours)	Alternative 5	Second Basis of Comparison (SBC)	Changes between Alternative 5 and SBC
CVP Facilities	Long-term Average	Energy Generation	4,552	4,604	-52
		Energy Use	1,110	1,289	-179
		Net Generation	3,442	3,315	127
	Dry and Critical Water Years	Energy Generation	2,684	2,773	-89
		Energy Use	699	773	-75
		Net Generation	1,986	2,000	-14
SWP Facilities	Long-term Average	Energy Generation	4,191	4,721	-530
		Energy Use	7,732	9,802	-2,070
		Net Generation	-3,541	-5,081	1,540

Project	Water Year	Energy (Gigawatt-hours)	Alternative 5	Second Basis of Comparison (SBC)	Changes between Alternative 5 and SBC
	Dry and Critical Water Years	Energy Generation	1,904	2,494	-590
		Energy Use	3,841	5,686	-1,845

Under Alternative 5 as compared to the Second Basis of Comparison, CVP and SWP water deliveries would be decreased and it is anticipated that CVP and SWP water users would use more alternate water supplies. Specific changes in energy use would depend upon specific responses by water users, and are not known at this time. Therefore, it is uncertain whether the increased regional and local water supply energy requirements would be similar to the decreased energy use by the CVP and SWP operations in 2030 under Alternative 5 as compared to the Second Basis of Comparison. For the purposes of this analysis, a worse-case scenario is assumed, and that total energy use by CVP and SWP water users could be higher under Alternative 5 as compared to the Second Basis of Comparison.

Effects Related to Cross Delta Water Transfers

Potential effects to energy 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 energy conditions would occur during implementation of cross Delta water transfers under Alternative 5 as compared to the Second Basis of Comparison.

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 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; however, energy resources conditions would be similar.

8.4.3.7 Summary of Impact Analysis

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 8.11 and 8.12.

Table 8.11 Comparison of Alternatives 1 through 5 to No Action Alternative

Alternative	Potential Change	Consideration for Mitigation Measures
Alternative 1	CVP annual net generation would be similar. SWP annual net generation would be increased by 41 percent over the long-term condition; and by 58 percent in dry and critical dry years. Total energy use by CVP and SWP water users, including energy for alternate water supplies, is assumed to decrease.	None needed.
Alternative 2	No effects on energy resources.	None needed.
Alternative 3	CVP annual net generation would be similar. SWP annual net generation would be increased by 27 percent over the long-term condition and by 16 percent in dry and critical dry years. Total energy use by CVP and SWP water users, including energy for alternate water supplies, is assumed to decrease.	None needed.
Alternative 4	Same effects as described for Alternative 1 compared to the No Action Alternative.	None needed.
Alternative 5	CVP and SWP annual net generation would be similar. Total energy use by CVP and SWP water users, including energy for alternate water supplies, is assumed to 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 No Action Alternative are considered to be “similar.”

Table 8.12 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	CVP annual net generation would be similar. SWP annual net generation would be reduced by 29 percent over the long-term condition and by 37 percent in dry and critical dry years. Total energy use by CVP and SWP water users, including energy for alternate water supplies, is assumed to increase.	Not considered for this comparison.
Alternative 1	No effects on energy resources.	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	CVP annual net generation would be similar. SWP annual net generation would be reduced by 10 percent over the long-term condition and by 58 percent in dry and critical dry years. Total energy use by CVP and SWP water users, including energy for alternate water supplies, is assumed to increase.	Not considered for this comparison.
Alternative 4	No effects on energy resources.	Not considered for this comparison.
Alternative 5	CVP annual net generation would be similar. SWP annual net generation would be reduced by 30 percent over the long-term condition and by 39 percent in dry and critical dry years. Total energy use by CVP and SWP water users, including energy for alternate water supplies, is assumed to increase.	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 No Action Alternative are considered to be “similar.”

8.4.3.8 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.

Changes under Alternatives 1 through 5 as compared to the No Action Alternative would result in similar or increased net energy generation, and reduced potential energy use by CVP and SWP water users for alternate water supplies. Therefore, there would be no adverse impacts to energy resources as compared to the No Action Alternative; and no mitigation measures are needed.

8.4.3.9 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 Energy Resources are summarized in Table 8.13.

Table 8.13 Summary of Cumulative Effects on Energy 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 and in All Alternatives in Year 2030	Consistent with Affected Environment conditions plus: Actions in the 2008 USFWS BO and 2009 NMFS BO that Would Have Occurred without Implementation of the Biological Opinions, as described in Section 3.3.1.2 (of Chapter 3, Descriptions of Alternatives), including climate change and sea level rise Actions not included in the 2008 USFWS BO and 2009 NMFS BO that Would Have Occurred without Implementation of the Biological Opinions, as described in Section 3.3.1.3 (of Chapter 3, Descriptions of Alternatives): - 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 - General plans for 2030. - Trinity River Restoration Program. - Central Valley Project Improvement Act programs	These effects would be the same in all alternatives. 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 carryover storage in reservoirs and changes in stream flow patterns in a manner that could reduce hydroelectric generation in the summer and fall months. Reduced CVP and SWP water deliveries south of the Delta would also reduce CVP and SWP electricity use. Future water supply projects are anticipated to both improve water supply reliability due to reduced surface water supplies and to accommodate planned growth in the general plans. It is anticipated that some of these projects could increase energy use, such as implementation of desalination projects.

Scenarios	Actions	Cumulative Effects of Actions
	- Folsom Dam Water Control Manual Update - FERC Relicensing for the Middle Fork of the American River Project - San Joaquin River Restoration Program - Future water supply projects, including water recycling, desalination, groundwater banks and wellfields, and conveyance facilities (projects with completed environmental documents)	However, other projects, such as water recycling, would not substantially increase energy use because most of the energy use was previously required for wastewater treatment. It is anticipated that energy required for water treatment of alternative water supplies would be similar as treatment for CVP and SWP water supplies. Increased use of groundwater pumps would increase energy use; however, this energy use would be similar or less than the energy used for CVP and SWP water conveyance. 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.
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): - Bay-Delta Water Quality Control Plan Update - FERC Relicensing Projects - Bay Delta Conservation Plan (including the California WaterFix alternative) - Shasta Lake Water Resources, North-of-the-Delta Offstream Storage, Los Vaqueros Reservoir Expansion Phase 2, and Upper San Joaquin River Basin Storage Investigations - El Dorado Water and Power Authority Supplemental Water Rights Project - Sacramento River Water Reliability Project - Semitropic Water Storage District Delta Wetlands - North Bay Aqueduct Alternative Intake - Irrigated Lands Regulatory Program	These effects would be the same in all alternatives. Most of the future reasonably foreseeable actions are anticipated to improve water supplies in California to reduce impacts due to climate change, sea level rise, increased water allocated to improve habitat conditions, and future growth. If CVP and SWP water supply reliability increases, energy use for conveyance of CVP and SWP water supplies also would increase. Some of the future reasonably foreseeable actions are anticipated to potentially reduce CVP and SWP water supply reliability (e.g., Water Quality Control Plan Update and FERC Relicensing Projects). Future water supply projects are anticipated to both improve water supply reliability due to reduced

Scenarios	Actions	Cumulative Effects of Actions
	- San Luis Reservoir Low Point Improvement Project - Westlands Water District v. United States Settlement - 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)	surface water supplies and to accommodate planned growth in the general plans. It is anticipated that some of these projects could increase energy use, such as implementation of desalination projects. However, other projects, such as water recycling, would not substantially increase energy use because most of the energy use was previously required for wastewater treatment. It is anticipated that energy required for water treatment of alternative water supplies would be similar as treatment for CVP and SWP water supplies. Increased use of groundwater pumps would increase energy use; however, this energy use would be similar or less than the energy used for CVP and SWP water conveyance.
No Action Alternative with Associated Cumulative Effects Actions in Year 2030	Full implementation of the 2008 USFWS BO and 2009 NMFS BO CVP and SWP	Implementation of No Action Alternative future reasonably foreseeable actions would result in changes stream flows and related changes in hydroelectric generation patterns, and reduced CVP and SWP water supplies as compared to conditions prior to the BOs. If CVP and SWP water supply reliability decreases, energy use for conveyance of CVP and SWP water supplies also would decrease and energy use for alternative water supplies could increase.
Alternatives 1 and 4 with Associated Cumulative Effects Actions 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 future reasonably foreseeable actions would result in changes in stream flows and related hydroelectric generation patterns, and increased CVP and SWP

Scenarios	Actions	Cumulative Effects of Actions
		water supplies as compared to the No Action Alternative with the added actions. Increased CVP and SWP water supply reliability would increase energy use for conveyance of CVP and SWP water supplies; and it is anticipated that energy use for alternative water supplies would decrease as compared to the No Action Alternative with the added actions.
Alternative 2 with Associated Cumulative Effects Actions Year 2030	Full implementation of the 2008 USFWS BO and 2009 NMFS BO CVP and SWP operational actions No implementation of structural improvements or other actions that require further study to develop a more detailed action description.	Implementation of Alternative 2 future reasonably foreseeable actions with future reasonably foreseeable actions for energy resources would be the same as for the No Action Alternative with the added actions.
Alternative 3 with Associated Cumulative Effects Actions 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) Slight increase in positive Old and Middle River flows in the winter and spring months	Implementation of Alternative 3 future reasonably foreseeable actions would result in changes in stream flows and related hydroelectric generation patterns, and increased CVP and SWP water supplies as compared to the No Action Alternative with the added actions. Increased CVP and SWP water supply reliability would increase energy use for conveyance of CVP and SWP water supplies; and it is anticipated that energy use for alternative water supplies would decrease as compared to the No Action Alternative with the added actions.
Alternative 5 with Associated Cumulative Effects Actions Year 20530	Full implementation of the 2008 USFWS BO and 2009 NMFS BO Positive Old and Middle River flows and increased Delta outflow in spring months	Implementation of Alternative 5 would result in changes in stream flows and related hydroelectric generation patterns, and reduced CVP and SWP water supplies as compared to the No Action

Scenarios	Actions	Cumulative Effects of Actions
		Alternative with the added actions. Reduced CVP and SWP water supply reliability would decrease energy use for conveyance of CVP and SWP water supplies; and it is anticipated that energy use for alternative water supplies would increase as compared to the No Action Alternative with the added actions.

8.5 References

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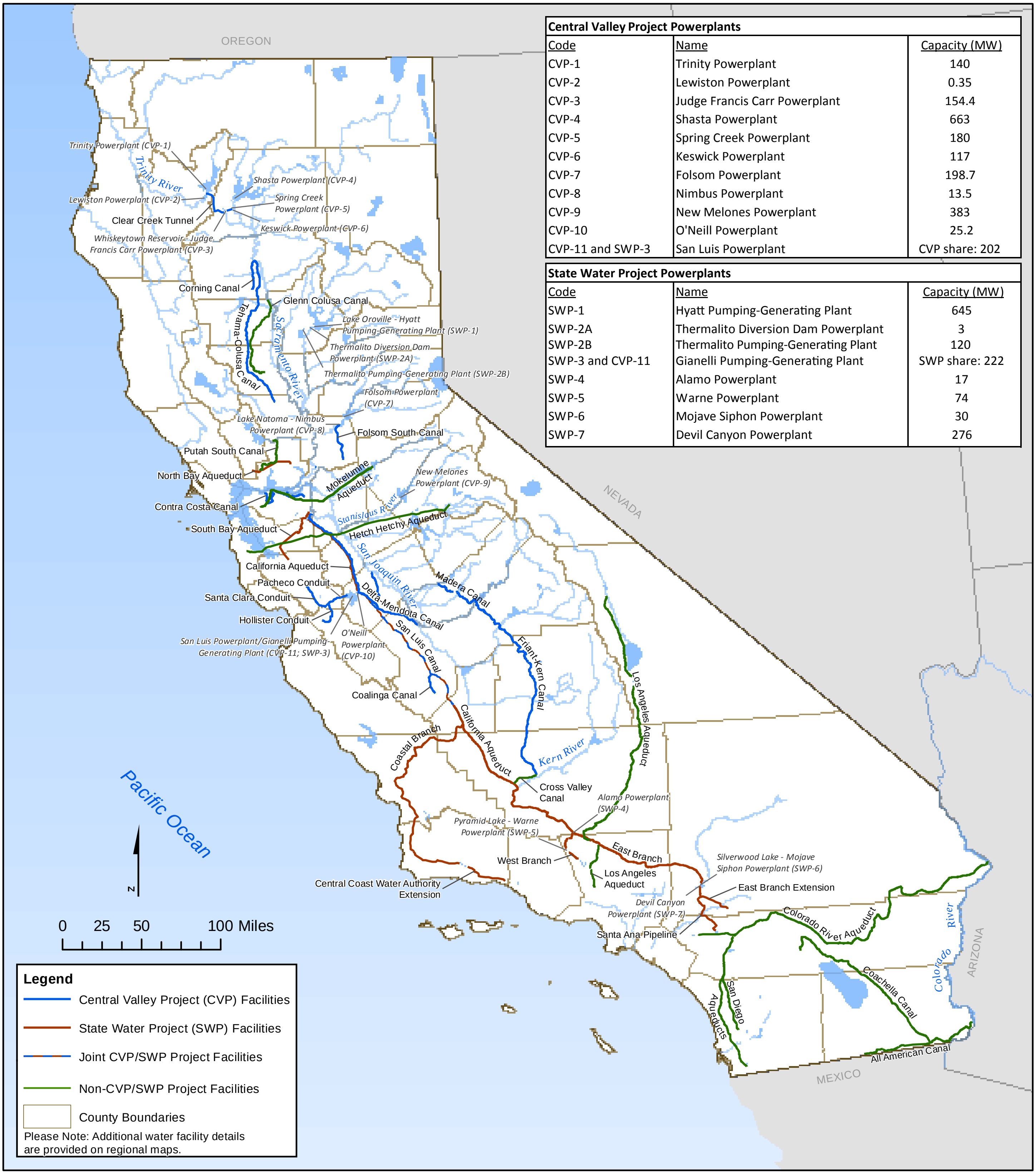
Chapter 8

Energy Figures

The following figures are included in Chapter 8, Energy.

- 8.1 Central Valley Project and State Water Project Hydroelectric Generation Facilities
- 8.2 Central Valley Project Energy Generation and Energy Use
- 8.3 State Water Project Energy Generation and Energy Use



Central Valley Project Powerplants

Code	Name	Capacity (MW)
CVP-1	Trinity Powerplant	140
CVP-2	Lewiston Powerplant	0.35
CVP-3	Judge Francis Carr Powerplant	154.4
CVP-4	Shasta Powerplant	663
CVP-5	Spring Creek Powerplant	180
CVP-6	Keswick Powerplant	117
CVP-7	Folsom Powerplant	198.7
CVP-8	Nimbus Powerplant	13.5
CVP-9	New Melones Powerplant	383
CVP-10	O'Neill Powerplant	25.2
CVP-11 and SWP-3	San Luis Powerplant	CVP share: 202

State Water Project Powerplants

Code	Name	Capacity (MW)
SWP-1	Hyatt Pumping-Generating Plant	645
SWP-2A	Thermalito Diversion Dam Powerplant	3
SWP-2B	Thermalito Pumping-Generating Plant	120
SWP-3 and CVP-11	Gianelli Pumping-Generating Plant	SWP share: 222
SWP-4	Alamo Powerplant	17
SWP-5	Warne Powerplant	74
SWP-6	Mojave Siphon Powerplant	30
SWP-7	Devil Canyon Powerplant	276

Figure 8.1 Central Valley Project and State Water Project Hydroelectric Generation Facilities

Sources: Reclamation 2013a, 2013b, 2013c, 2013d, 2013e, 2013f, 2013g, 2013h, 2013i, 2013j, 2013k, 2013l; DWR 2012

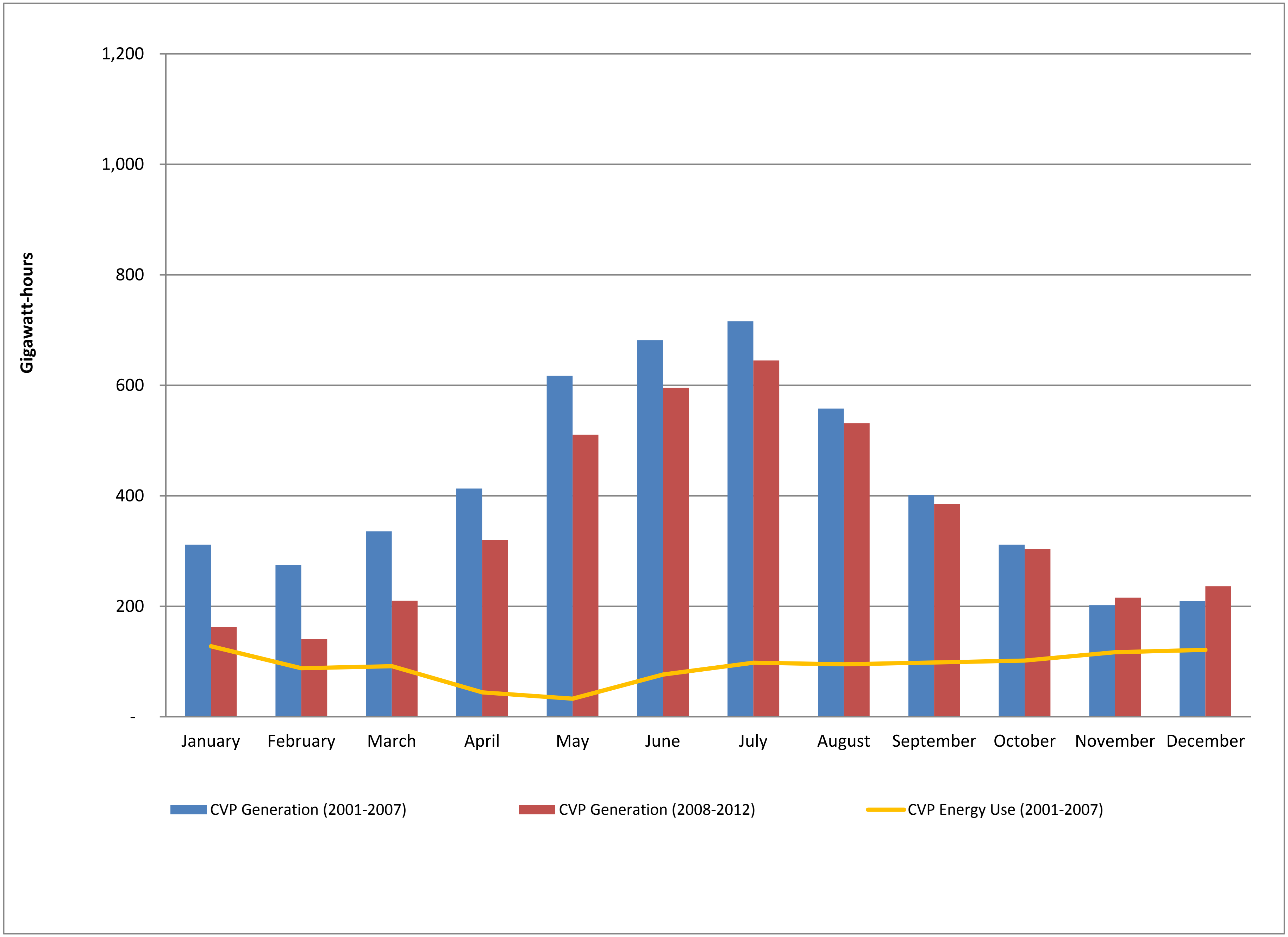


Figure 8.2 Central Valley Project Energy Generation and Energy Use

Sources: Reclamation 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008 a-l, 2009a-l, 2010a-l, 2011a-l, 2012a-l

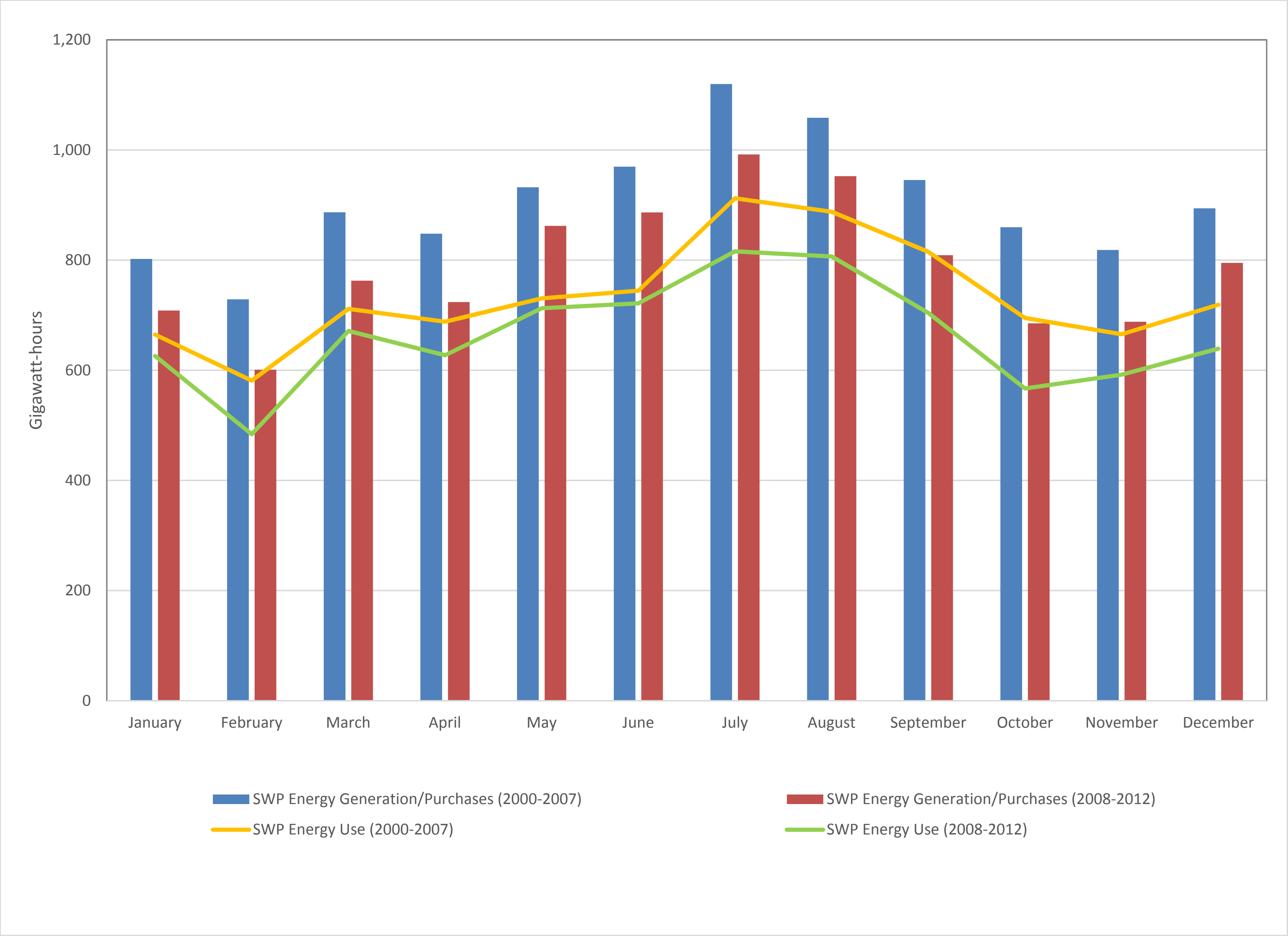


Figure 8.3 State Water Project Energy Generation and Energy Use
Sources: DWR 2002, 2004a, 2004b, 2005, 2006, 2007, 2008, 2012a, 2012b, 2013

Chapter 9

Fish and Aquatic Resources

9.1 Introduction

This chapter describes the fish and aquatic resources that occur in the portions of the project area that could be affected as a result of implementing the alternatives evaluated in this Environmental Impact Statement (EIS). Implementation of the alternatives could affect aquatic resources through changes in ecological attributes as a result of potential changes in long-term operation of the Central Valley Project (CVP) and State Water Project (SWP) and ecosystem restoration.

9.2 Regulatory Environment and Compliance Requirements

Potential actions implemented under the alternatives evaluated in this EIS could affect fish and aquatic resources. 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.

9.3 Affected Environment

This section describes fish and aquatic resources that could be affected by the implementation of the alternatives considered in this EIS. Changes in aquatic 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.

The following description of the affected environment focuses on CVP and SWP reservoirs, rivers downstream of CVP and SWP reservoirs, the Sacramento-San Joaquin Rivers Delta Estuary (Delta), and conditions downstream of the Delta that are affected by operation of the CVP and SWP.

This section is organized by geographic area, generally in an upstream to downstream direction. This format does not necessarily coincide with the use by fish and aquatic species, which can move among geographic areas either seasonally or during different phases of their life history.

The descriptions of species and biological and hydrodynamic processes in this chapter frequently use the terms “Delta” and “San Francisco Estuary.” The Delta refers to the Sacramento-San Joaquin Delta, as legally defined in the Delta Protection Act. The San Francisco Estuary refers to the portion of the Sacramento-San Joaquin Rivers watershed downstream of Chipps Island that is influenced by tidal action and where fresh water and salt water mix, which includes the following waterbodies: Suisun, San Pablo, and San Francisco bays.

9.3.1 Fish and Aquatic Species Evaluated

Many fish and aquatic species use the project area during all or some portion of their lives; however, certain fish and aquatic species were selected to be the focus of the analysis of alternatives considered in this EIS based on their sensitivity and their potential to be affected by changes in the operation of the CVP and SWP implemented under the alternatives considered in this EIS, as summarized in Table 9.1. While many of the species identified in Table 9.1 also occur in tributaries to the major rivers, the focus of this EIS is on the waterbodies influenced by operations of the CVP and SWP. Operation of the CVP and SWP would not directly affect ocean conditions; however, operations have the potential to affect Southern Resident Killer Whales indirectly by influencing the number of Chinook Salmon (produced in the Sacramento-San Joaquin River and associated tributaries) that enter the Pacific Ocean and become available as a food supply for the whales.

These focal species are fish and marine mammal species listed as threatened or endangered or at risk of being listed as endangered or threatened, legally protected, or are otherwise considered sensitive by the U.S. Fish and Wildlife Service (USFWS), National Marine Fisheries Service (NMFS), or California Department of Fish and Wildlife (CDFW) (previously known as Department of Fish and Game [DFG]) and fish that have tribal, commercial or recreational importance. In addition, salmon, steelhead, sturgeon, Striped Bass, and American Shad are managed in accordance with Section 3406of the Central Valley Project Improvement Act. Details on the status, life history, habitat requirements, and population trends for each of the aquatic focal species are provided in Appendix 9B.

Table 9.1 Focal Fish Species by Region of Occurrence

Species or *Population*[a]	Federal Status	State Status[b]	Tribal, Commercial, or Recreational Importance	Occurrence within Area of Analysis
Trinity River Region				
Coho Salmon *Southern Oregon/Northern California Coast ESU*	Threatened	Threatened	Yes	Trinity River, Klamath River
Eulachon *Southern DPS*	Threatened	None	Yes	Klamath River
Green Sturgeon *Southern DPS*	Threatened	Species of Special Concern	Yes	Trinity River, Klamath River
Spring-run Chinook Salmon *Upper Klamath-Trinity River ESU*	None	Species of Special Concern	Yes	Trinity River, Klamath River
Steelhead (winter- and summer-run) *Klamath Mountains Province DPS*	None	Species of Special Concern[c]	Yes	Trinity River, Klamath River
American Shad	None	None	Yes	Trinity River
Pacific Lamprey	None	None	Yes	Trinity River, Klamath River

Species or *Population*[a]	**Federal Status**	**State Status[b]**	**Tribal, Commercial, or Recreational Importance**	**Occurrence within Area of Analysis**
White Sturgeon	None	None	Yes	Trinity River, Klamath River
Black Bass (Largemouth, Smallmouth, Spotted)	None	None	Yes	Trinity River
Central Valley Region				
Winter-run Chinook Salmon *Sacramento River ESU*	Endangered	Endangered	Yes	Sacramento River[d], Delta, and Suisun Marsh
Spring-run Chinook Salmon *Central Valley ESU*	Threatened	Threatened	Yes	Clear Creek, Sacramento River, Feather River, American River, Delta, and Suisun Marsh
Steelhead *Central Valley DPS*	Threatened	None	Yes	Clear Creek, Feather River, Sacramento River; American River, Stanislaus River, San Joaquin River, Delta and Suisun Marsh
Green Sturgeon *Southern DPS*	Threatened	Species of Special Concern	Yes	Feather River, Sacramento River, Delta and Suisun Marsh
Delta Smelt	Threatened	Endangered	No	Delta and Suisun Marsh
Longfin Smelt *Bay Delta DPS*	Candidate	Threatened	No	Delta and Suisun Marsh
Fall-/late Fall-run Chinook Salmon *Central Valley ESU*	None	Species of Special Concern	Yes	Clear Creek, Feather River, Sacramento River, American River, Stanislaus River, San Joaquin River, Delta and Suisun Marsh
Sacramento Splittail	None	Species of Special Concern	No	Feather River, American River, Sacramento River, Delta and Suisun Marsh, San Joaquin River
Hardhead	None	Species of Special Concern	No	Clear Creek, Feather River, Sacramento River, American River, Delta, Stanislaus River, San Joaquin River
Sacramento-San Joaquin Roach	None	Species of Special Concern	No	Clear Creek, Feather River, American River, Sacramento River, Delta, Stanislaus River, San Joaquin River

Species or *Population*[a]	Federal Status	State Status[b]	Tribal, Commercial, or Recreational Importance	Occurrence within Area of Analysis
River Lamprey	None	None	Yes	Feather River, American River, Sacramento River, Delta and Suisun Marsh, Stanislaus River, San Joaquin River
Pacific Lamprey	None	None	Yes	Clear Creek, Feather River, Sacramento River, American River, Delta, Stanislaus River, San Joaquin River
White Sturgeon	None	None	Yes	Feather River, Sacramento River, American River, San Joaquin River, Delta and Suisun Marsh
American Shad	None	None	Yes	Feather River, American River, Sacramento River, Delta and Suisun Marsh, Stanislaus River, San Joaquin River
Black Bass (Largemouth, Smallmouth, Spotted)	None	None	Yes	Feather River, American River, Sacramento River, Delta and Suisun Marsh, Stanislaus River, San Joaquin River
Striped Bass	None	None	Yes	Feather River, American River, Sacramento River, Delta and Suisun Marsh, Stanislaus River, San Joaquin River
San Francisco Bay and Pacific Ocean Waters				
Steelhead Central California Coast DPS	Threatened	None	Yes	San Francisco Bay region
Killer Whale *Southern Resident DPS*	Endangered	None	Yes	Pacific Coast

Notes:

a. The term *population* refers to the listed Evolutionarily Significant Unit (ESU) or Distinct Population Segment (DPS) for that species.

b. Includes species listed by the State of California as threatened, endangered, or considered a Species of Special Concern.

c. The California Species of Special Concern designation refers only to the summer-run of the Klamath Mountains Province DPS steelhead population

d. Also includes lower reaches of tributaries (e.g., American River) used for nonnatal rearing areas by juvenile salmon.

The life history attributes (e.g., timing of juvenile outmigration) for most of the species listed above, along with the ecological attributes important to the species and potentially influenced by the alternatives, are discussed in this chapter according to the geographic areas (regions/subregions) where the species occurs; Pacific Lamprey, Green Sturgeon, White Sturgeon, American Shad, and Striped Bass are discussed in detail only in those regions where they spend the majority of their life cycle such that geographic information is available. There are also several species (i.e., River Lamprey, Sacramento-San Joaquin Roach, and Hardhead) for which little geographic information is available; therefore, they are not discussed in detail in this chapter, but are described in the species accounts presented in Appendix 9B. Additionally, these species are only generally addressed in the analysis of impacts presented in the Environmental Consequences section of this chapter.

The level of detail presented in the Affected Environment section is tailored to correspond the level of resolution of the analysis, which relies on modeling tools that broadly characterize the changes in CVP and SWP operations on reservoir storage and flows. This level of detail is intended to support an understanding of the resources potentially affected and the context within which the project is evaluated. The inclusion of unnecessary detail is avoided.

9.3.2 Critical Habitat

Critical habitat refers to areas designated by USFWS or NMFS for the conservation of their jurisdictional species listed as threatened or endangered under the Endangered Species Act (ESA). When a species is proposed for listing under the ESA, USFWS or NMFS considers whether there are certain areas essential to the conservation of the species. Critical habitat is defined in Section 3, Provision 5 of the ESA as follows.

> *(5)(A) The term “critical habitat” for a threatened or endangered species means–*
>
> > *(i) the specific areas within the geographical area occupied by a species at the time it is listed in accordance with the Act, on which are found those physical or biological features (I) essential to the conservation of the species, and (II) which may require special management considerations or protection; and*
> >
> > *(ii) specific areas outside the geographical area occupied by a species at the time it is listed in accordance with the provisions of section 4 of this Act, upon a determination by the Secretary that such areas are essential for the conservation of the species.*

Any Federal action (permit, license, or funding) in critical habitat requires that the Federal agency consult with USFWS or NMFS where the action has potential to adversely modify the habitat for the listed species.

ESA regulations state that the physical and biological features essential to the conservation of the species include space for individual and population growth and for normal behavior; food, water, air, light, minerals, or other nutritional or physiological requirements; cover or shelter; sites for breeding, reproduction, and rearing of offspring; and habitats that are protected from disturbance or are representative of the historical geographical and ecological distribution of a species. These principal biological and physical features are known as Primary Constituent Elements (PCEs)[1]. Specific PCEs identified for salmonids, Green Sturgeon, Delta Smelt, and Eulachon are described below.

9.3.2.1 Anadromous Salmonids

In designating critical habitat for anadromous salmonids (70 Federal Register [FR] 52536), NMFS identified the following PCEs as essential to the conservation of the listed populations:

- Freshwater spawning sites with water quantity and quality conditions and substrate that support spawning, incubation, and larval development.
- Freshwater rearing sites with:
  - Water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility
  - Water quality and forage supporting juvenile development
  - Natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks
- Freshwater migration corridors free of obstruction and excessive predation with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival.
- Estuarine areas free of obstruction and excessive predation with:
  - Water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh water and salt water
  - Natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels
  - Juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation

Critical habitat in nontidal waters includes the stream channels in the designated stream reaches, the lateral extent of which generally defined by the ordinary high-water line.

9.3.2.1.1 Central Valley Spring-run Chinook Salmon ESU

This ESU consists of spring-run Chinook Salmon in the Sacramento River Basin, including spring-run Chinook Salmon from the Feather River Hatchery. Designated critical habitat for Central Valley spring-run Chinook Salmon includes stream reaches of the American, Feather, Yuba, and Bear rivers;

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[1] The U.S. Fish and Wildlife Service and National Marine Fisheries Service have proposed discontinuing the use of the term “Primary Constituent Elements” to simplify and clarify the critical habitat process and to provide consistency with the language contained in the Endangered Species Act, which uses the term “physical or biological features.”

tributaries of the Sacramento River, including Big Chico, Butte, Deer, Mill, Battle, Antelope, and Clear creeks; and the main stem of the Sacramento River from Keswick Dam through the Delta. Designated critical habitat in the Delta includes portions of the Delta Cross Channel (DCC); Yolo Bypass; and portions of the network of channels in the northern Delta. Critical habitat for spring-run Chinook Salmon was not designated for the Stanislaus or San Joaquin River.

The spring-run Chinook Salmon critical habitat potentially affected by operation of the CVP and SWP includes the network of channels in the northern Delta, Sacramento River up to Keswick Dam, Clear Creek up to Whiskeytown Dam, the Feather River up to the Fish Barrier Dam, and the American River up to Watt Avenue in the Sacramento Valley subregion. The section of the American River denoted as critical habitat serves only as juvenile nonnatal rearing habitat; spring-run Chinook Salmon do not spawn in the American River. Operation of the CVP and SWP would have no effect on designated critical habitat for spring-run Chinook Salmon in the Yuba River and Big Chico, Butte, Deer, Mill, Battle, and Antelope creeks or other tributaries of the Sacramento River. Operation of the CVP and SWP could affect designated critical habitat in the Delta subregion. There is no designated critical habitat for spring-run Chinook Salmon in the San Joaquin Valley subregion.

9.3.2.1.2 Sacramento River Winter-run Chinook Salmon ESU

The Sacramento River winter-run Chinook Salmon ESU consists of only one population confined to the upper Sacramento River. This ESU includes all fish spawning naturally in the Sacramento River and its tributaries, as well as fish that are propagated at the Livingston Stone National Fish Hatchery (NFH), operated by USFWS (NMFS 2005a). Critical habitat was delineated as the Sacramento River from Keswick Dam to Chipps Island at the westward margin of the Delta; all waters from Chipps Island westward to the Carquinez Bridge, including Honker Bay, Grizzly Bay, Suisun Bay, and the Carquinez Strait; all waters of San Pablo Bay westward of the Carquinez Bridge; and all waters of San Francisco Bay (north of the San Francisco-Oakland Bay Bridge) to the Golden Gate Bridge (NMFS 1993).

9.3.2.1.3 Central Valley Steelhead DPS

The California Central Valley Steelhead DPS includes all naturally spawned populations of steelhead in the Sacramento and San Joaquin rivers and their tributaries, excluding steelhead from San Francisco and San Pablo bays and their tributaries. Two artificial propagation programs, the Coleman NFH and Feather River Hatchery steelhead hatchery programs, are considered to be part of the DPS. Critical habitat for Central Valley Steelhead includes stream reaches of the American, Feather, Yuba, and Bear rivers and their tributaries, and tributaries of the Sacramento River including Deer, Mill, Battle, Antelope, and Clear creeks in the Sacramento River Basin; the Mokelumne, Calaveras, Stanislaus, Tuolumne, and Merced rivers in the San Joaquin River Basin; and portions of the Sacramento and San Joaquin rivers. Designated critical habitat in the Delta includes portions of the DCC, Yolo Bypass, Ulatis Creek, and portions of the network of channels in the Sacramento River portion of the Delta; and portions of the San Joaquin, Cosumnes, and Mokelumne rivers and portions of the network of channels in the San Joaquin portion of the Delta.

The Central Valley Steelhead critical habitat potentially affected by operation of the CVP and SWP includes the Sacramento River up to Keswick Dam, Clear Creek up to Whiskeytown Dam, the Feather River up to the Fish Barrier Dam, and the American River up to Nimbus Dam in the Sacramento Valley subregion. Operation of the CVP and SWP would have no effect on designated critical habitat for steelhead in the Yuba River and Big Chico, Butte, Deer, Mill, Battle, and Antelope creeks or other tributaries of the Sacramento River.

9.3.2.1.4 Central California Coast Steelhead DPS

The Central California Coast Steelhead DPS includes all naturally spawned populations of steelhead in streams from the Russian River to Aptos Creek, Santa Cruz County (inclusive). It also includes the drainages of San Francisco and San Pablo bays. Critical habitat for Central California Coast Steelhead includes stream reaches in the Russian River, Bodega, Marin Coastal, San Mateo, Bay Bridge, Santa Clara, San Pablo, and Big Basin Hydrologic Units. Operation of the CVP and SWP would not affect designated critical habitat for this DPS of Central California Coast Steelhead, and NMFS (2009a) concluded that operation would not likely adversely affect individual fish; therefore, this species is not addressed in this EIS.

9.3.2.1.5 Southern Oregon/Northern California Coastal Coho Salmon ESU

The Southern Oregon/Northern California Coast Coho Salmon ESU consists of populations from Cape Blanco, Oregon, to Punta Gorda, California, including Coho Salmon in the Trinity River. In the Trinity River Region, all Trinity River reaches downstream of Lewiston Dam, the south fork of the Trinity River, and the entire lower Klamath River are designated as critical habitat with the exception of tribal lands (NMFS 1999).

9.3.2.2 North American Green Sturgeon Southern DPS

The North American Green Sturgeon Southern DPS consists of coastal and Central Valley populations south of the Eel River, with the only known spawning population in the Sacramento River. In designating critical habitat for the North American Green Sturgeon Southern DPS, NMFS (74 FR 52345) identified PCEs as essential to the conservation of this species in freshwater riverine systems, estuarine areas, and nearshore marine waters. The PCEs for each area largely overlap and include the following items:

- **Food Resources.** Abundant prey items for larval, juvenile, subadult, and adult life stages.
- **Substrate Type or Size (i.e., structural features of substrates).** Substrates suitable for egg deposition and development (e.g., bedrock sills and shelves, cobble and gravel, or hard clean sand, with interstices or irregular surfaces to “collect” eggs and provide protection from predators, and free of excessive silt

and debris that could smother eggs during incubation), larval development (e.g., substrates with interstices or voids providing refuge from predators and from high-flow conditions), and subadults and adults (e.g., substrates for holding and spawning).

- **Water Flow.** A flow regime (i.e., the magnitude, frequency, duration, seasonality, and rate-of-change of fresh water discharge over time) necessary for normal behavior, growth, and survival of all life stages.
- **Water Quality.** Water quality, including temperature, salinity, oxygen content, and other chemical characteristics, necessary for normal behavior, growth, and viability of all life stages.
- **Migratory Corridor.** A migratory pathway necessary for the safe and timely passage of Southern DPS fish within riverine habitats and between riverine and estuarine habitats (e.g., an unobstructed river or dammed river that still allows for safe and timely passage).
- **Water Depth.** Deep (greater than 5 meters [m]) holding pools for both upstream and downstream holding of adult or subadult fish, with adequate water quality and flow to maintain the physiological needs of the holding adult or subadult fish.
- **Sediment Quality.** Sediment quality (i.e., chemical characteristics) necessary for normal behavior, growth, and viability of all life stages.

Critical habitat in freshwater riverine habitats includes the stream channels in the designated stream reaches with the lateral extent defined by the ordinary high-water line. The ordinary high-water line on nontidal rivers is defined as “the line on the shore established by the fluctuations of water and indicated by physical characteristics such as a clear, natural line impressed on the bank; shelving; changes in the character of soil; destruction of terrestrial vegetation; the presence of litter and debris, or other appropriate means that consider the characteristics of the surrounding areas” [33 Code of Federal Regulations 329.11(a)(1)].

Within the study area, critical habitat includes the Sacramento River from the I-Street Bridge upstream to Keswick Dam, including areas in the Yolo Bypass and the Sutter Bypass and the lower American River from the confluence with the Sacramento River upstream to the State Route 160 bridge over the American River; the lower Feather River from the confluence with the Sacramento River upstream to the Fish Barrier Dam; and the lower Yuba River from the confluence with the Feather River upstream to Daguerre Dam. Critical habitat also includes all waterways of the Delta up to the elevation of mean higher high water except for certain excluded areas and all tidally influenced areas of San Francisco Bay, San Pablo Bay, and Suisun Bay up to the elevation of mean higher high water (NMFS 2009b).

9.3.2.3 Delta Smelt

In designating critical habitat for Delta Smelt (59 FR 65256), USFWS identified the following PCEs essential to the conservation of the species: (1) suitable substrate for spawning; (2) water of suitable quality and depth to support survival and reproduction (e.g., temperature, turbidity, lack of contaminants); (3) sufficient Delta flow to facilitate spawning migrations and transport of larval Delta Smelt to appropriate rearing habitats; and (4) salinity, which influences the extent and location of the low salinity zone where Delta Smelt rear. The location of the low salinity zone (or X2) is described in terms of the average distance of the two practical salinity units isohaline from the Golden Gate Bridge. Critical habitat for Delta Smelt includes all water and submerged lands below ordinary high water and the entire water column bounded by and contained in Suisun Bay (including the contiguous Grizzly and Honker bays); the length of Goodyear, Suisun, Cutoff, First Mallard (Spring Branch), and Montezuma sloughs; and the existing contiguous waters contained in the legal Delta (as defined in Section 12220 of the California Water Code) (USFWS 1994a).

9.3.2.4 Eulachon Southern DPS

In designating critical habitat for Eulachon, NMFS (76 FR 65323) identified the following physical or biological features essential to the conservation of the Eulachon Southern DPS fall reflecting key life history phases of Eulachon: (1) freshwater spawning and incubation sites with water flow, quality and temperature conditions and substrate supporting spawning and incubation, and with migratory access for adults and juveniles; (2) freshwater and estuarine migration corridors associated with spawning and incubation sites that are free of obstruction and with water flow, quality and temperature conditions supporting larval and adult mobility, and with abundant prey items supporting larval feeding after the yolk sac is depleted; and (3) nearshore and offshore marine foraging habitat with water quality and available prey, supporting juveniles and adult survival.

Within the study area, critical habitat for Eulachon includes the Klamath River from the mouth upstream to the confluence with Omogar Creek. The critical habitat designation specifically excludes all lands of the Yurok Tribe and Reshigini Rancheria, based upon a determination that the benefits of exclusion outweigh the benefits of designation (NMFS 2011b). Exclusion of these areas will not result in the extinction of the Southern DPS because the overall percentage of critical habitat on Indian lands is so small (approximately 5 percent of the total are designated), and it is likely that Eulachon production on these lands represents a small percent of the total annual production for the DPS (NMFS 2011a, 2011b).

9.3.3 Trinity River Region

The Trinity River Region includes Trinity Lake, Lewiston Reservoir and the Trinity River from Lewiston Reservoir to the confluence with the Klamath River; and the portion of the lower Klamath River watershed in Humboldt and Del Norte counties from the confluence with the Trinity River to the Pacific Ocean. The

CVP Trinity Lake and Lewiston Reservoir are located upstream of the confluences of several Trinity River tributaries (i.e., north fork, south fork, and New River) and flows on these tributaries are not affected by CVP facilities. The Trinity River flows approximately 112 miles from Lewiston Reservoir to its confluence with the Klamath River, traversing through Trinity and Humboldt counties and the Hoopa Indian Reservation within Trinity and Humboldt counties. The Trinity River is the largest tributary to the Klamath River (DOI and DFG 2012).

The lower Klamath River flows 43.5 miles from the confluence with the Trinity River to the Pacific Ocean (USFWS et al. 1999). Downstream of the Trinity River confluence, the Klamath River flows through Humboldt and Del Norte counties and through the Hoopa Indian Reservation, Yurok Indian Reservation, and Resighini Indian Reservation within Humboldt and Del Norte counties (DOI and DFG 2012). There are no dams located in the Klamath River watershed downstream of the confluence with the Trinity River. The Klamath River estuary extends from approximately 5 miles upstream of the Pacific Ocean. This area is generally under tidal effects, and salt water can occur up to 4 miles from the coastline during high tides in summer and fall when Klamath River flows are low.

9.3.3.1 Trinity Lake and Lewiston Reservoir

Trinity Lake is created by Trinity Dam and is considered relatively unproductive, with low-standing crops of phytoplankton and zooplankton (USFWS et al. 2004). The fish in Trinity Lake include cold-water and warm-water species. Trinity Lake supports a trophy Smallmouth Bass fishery and provides substantial sport fishing for Largemouth Bass, Rainbow and Brown Trout, and Kokanee Salmon (landlocked Sockeye Salmon). Other fish species in Trinity Lake include Speckled Dace, Klamath Smallscale Sucker, Coast Range Sculpin, and the nonnative Green Sunfish and Brown Bullhead.

Lewiston Reservoir is a re-regulating reservoir for Trinity Lake. The water surface elevation is relatively constant. The reservoir contains Rainbow, Brown, and Brook Trout and Kokanee Salmon. Other fish species present include Pacific Lamprey, Speckled Dace, Klamath Smallscale Sucker, Coast Range Sculpin, and Smallmouth Bass (USFWS et al. 2004).

9.3.3.2 Trinity River from Lewiston Reservoir to Klamath River

The Trinity River flows out of Trinity Lake and Lewiston Reservoir. Native anadromous salmonids in the mainstem Trinity River and its tributaries downstream of Lewiston Dam are spring- and fall-run Chinook Salmon, Coho Salmon, and steelhead (NCRWQCB et al. 2009). Native non-salmonid anadromous species that inhabit the Trinity River Basin include Green Sturgeon, White Sturgeon, Pacific Lamprey, and Eulachon.

The hydrologic and geomorphic changes following construction of the Trinity and Lewiston dams changed the character of the river channel substantially and altered the quantity and quality of aquatic habitat. Riparian vegetation was allowed to encroach on areas that had previously been scoured by flood flows, resulting in the formation of a riparian berm that armored and anchored the river banks and prevented meandering of the river channel (USFWS et al. 1999). The berm reduced the potential for encroachment and maturation of woody vegetation along the stabilized channel.

The ongoing Trinity River Restoration Program includes specific minimum instream flows (as described in Chapter 5, Surface Water Resources and Water Supplies); mechanical channel rehabilitation; fine and coarse sediment management; watershed restoration; infrastructure improvement; and adaptive management components (NCRWQCB et al. 2009, USFWS et al. 1999). The mechanical channel rehabilitation includes removal of fossilized riparian berms that had been anchored by extensive woody vegetation root systems and had confined the river. Following removal of the berms, the areas have been re-vegetated to support native vegetation, re-establish alternate point bars, and re-establish complex fish habitat similar to conditions prior to construction of the dams. Sediment management activities include introduction of coarse sediment at locations to support spawning and other aquatic life stages; and relocation of sand outside of the floodway. In areas closer to Lewiston Dam with limited gravel supply, gravel/cobble point bars are being rebuilt to increase gravel storage and improve channel dynamics. Riparian vegetation planted on the restored floodplains and flows will be managed to encourage natural riparian growth on the floodplain and limit encroachment on the newly formed gravel bars. Improvement projects have been completed and others are under construction or in the planning phases. These restoration actions are occurring in the 40-mile restoration reach between Lewiston Dam and the confluence with north fork of the Trinity River (TRRP 2014).

9.3.3.2.1 Fish in the Trinity River

The following focal fish species that occur in the Trinity River are considered in this EIS.

- Coho Salmon
- Chinook Salmon (spring- and fall-run)
- Steelhead (winter-and summer-run)
- Green Sturgeon
- White Sturgeon
- Pacific Lamprey
- American Shad

Coho Salmon

Coho Salmon in the Trinity River are thought to be exclusively 3-year lifecycle fish, living a full year in the river as juveniles before migrating to the ocean. Most returning adult Coho Salmon enter rivers between August and January. Spawning in the Trinity River and tributaries occurs primarily in November and December. Most of the spawning by Coho Salmon in the mainstem Trinity River occurs from Lewiston Dam downstream to the North Fork Trinity confluence (NMFS 2014a). Coho Salmon eggs incubate from 35 to more than 100 days, depending on water temperature, and emerge from the gravel 2 weeks to 7 weeks after hatching. Because juvenile Coho Salmon remain in their spawning stream for a full year after emerging from the gravel, they are exposed to a broad range of freshwater conditions. Coho Salmon smolts typically migrate to the ocean between March and June, with most leaving in April and May (the term “smolt” refers to young salmon prior to entering the ocean that have undergone the physiological changes necessary for life in salt water).

Coho Salmon were not likely the dominant species of salmon in the Trinity River before dam construction. However, the species was widespread in the Trinity River Basin, ranging as far upstream as Stuarts Fork above present-day Trinity Dam. Passage for Coho Salmon and other anadromous salmonids is now blocked at Lewiston Dam, which prevents access to roughly 109 miles of upstream habitat for Coho Salmon (DOI 2000). The Trinity River Salmon and Steelhead Hatchery (Trinity River Hatchery) produces Coho Salmon with an annual production goal of 500,000 yearlings to mitigate the upstream habitat loss (CHSRG 2012).

Several interrelated factors affect Coho Salmon abundance and distribution in the Trinity River. These factors include degradation of spawning and rearing habitat, sparse spawning gravel recruitment, lack of deep pools, stressful late summer water temperatures, water diversions, channelization and confinement, irregular timing of flows, fragmentation of populations, genetic and ecological interactions with hatchery salmonids, migration barriers, water quality problems, and unscreened diversions (NMFS 2014a). Current CVP operations primarily affect water temperature, water flow, and habitat suitability in the Trinity River (Reclamation 2008a). Currently accessible habitat downstream of Lewiston Dam represents about 50 percent of historically available habitat (USFWS 1999).

Habitat in the Trinity River has changed since flow regulation that began with the completion of Trinity and Lewiston dams, with the encroachment of riparian vegetation restricting channel movement and limiting fry rearing habitat (Trush et al. 2000). The Trinity River Restoration Program is implemented to provide higher peak flows to restore attributes of a fully functioning alluvial river, such as alternating bar features and additional off-channel habitat, and to provide better rearing habitat for Coho Salmon (Reclamation 2008a, TRRP 2013). Several restoration actions have been completed to reconnect the river with the floodplain, including selective removal of terraces and riparian berms and physical alteration of the adjacent floodplain to increase inundation frequency. Releases from Trinity Lake occur on a variable flow schedule with higher spring releases to promote the restored geomorphic processes and habitat.

An estimated 21,906 adult Coho Salmon migrated into the Trinity River Basin upstream of Willow Creek (about 88 miles downstream of Lewiston Dam) in 2013, of which 6,631 entered Trinity River Hatchery (located near Lewiston Dam) and 15,275 were estimated to have spawned in the river (CDFW 2014). The run-size estimates have ranged from 852 fish in 1994 to 59,079 fish in 1987. The 2011 run was ranked 10th of the 37 years on record and is 27.6 percent of the 17,161 average (CDFW 2014). Both intra- and inter-specific redd superimposition on the spawning grounds can affect salmon reproductive success and the spawning areas downstream of Lewiston Dam are likely near carrying capacity (NMFS 2014a).

Spring-run Chinook Salmon

Adult spring-run Chinook Salmon migrate upstream in the Trinity River from April through September, with most fish arriving at the mouth of the North Fork Trinity by the end of July. These fish remain in deep pools until the onset of the spawning season, which typically begins the third week of September, peaks in October, and continues through November. The distribution of spawning extends upstream to Lewiston Dam, and is concentrated in the reaches immediately downstream of the dam to the mouth of the North Fork Trinity River. Williams et al. (2011) concluded that although abundance is low compared with historical abundance, the current spring-run Chinook Salmon population (which includes hatchery fish) appears to have been fairly stable for the past 30 years. In 2013, an estimated 8,961 spring-run Chinook Salmon entered the Trinity River upstream of Junction City, including the 2,578 fish that entered the Trinity River Hatchery and 6,129 natural area spawners CDFW 2014). This run-size estimate is approximately 51 percent of the 34-year average spring-run Chinook Salmon run-size of 17,402, which has ranged from 2,381 fish in 1991 to 62,692 fish in 1988 (CDFW 2014).

Emergence of spring-run Chinook Salmon fry in the Trinity River begins in December and continues into mid-April. Juvenile spring-run Chinook Salmon typically outmigrate after a year of growth in the Trinity River. Outmigration from the lower Trinity River, as indicated by monitoring near Willow Creek, peaks in May and June.

Fall-run Chinook Salmon

The adult fall-run Chinook Salmon migration in the Trinity River begins in August and continues into December, with spawning beginning in mid-October. Spawning activity peaks in November, and continues through December. Spawning of fall-run Chinook Salmon occurs throughout the mainstem Trinity River from Lewiston Dam to the Hoopa Valley (Myers et al. 1998). The first spawning activity usually occurs just downstream from Lewiston Dam and extends farther downstream as the spawning season progresses.

Like spring-run Chinook Salmon, emergence of fall-run Chinook Salmon fry begins in December and continues into mid-April. Juvenile fall-run Chinook Salmon typically outmigrate after a few months of growth in the Trinity River. Outmigration from the upper river, as indicated by monitoring near Junction City, begins in March and peaks in early May, ending by late May or early June. Outmigration of fall-run Chinook Salmon fry in the lower Trinity River occurs over approximately the same time period described above for the spring run.

An estimated 36,989 fall-run Chinook Salmon migrated into the Trinity River upstream of Willow Creek in 2013, of which 3,852 entered Trinity River Hatchery and 32,257 spawned naturally (CDFW 2014). This estimate is approximately 84.5 percent of the 43,762 mean run-size for the years since 1977, which has ranged from 9,207 fish in 1991 to 147,888 fish in 1986 (CDFW 2014).

Steelhead

Steelhead in the Trinity River exhibit two primary life history strategies: a summer-run that is stream maturing and a winter-run that is ocean maturing. The winter-run is considered by some to be composed of a fall-run and a winter-run based upon the timing of the adult migration. Summer-run steelhead have been observed in the north and south forks of the Trinity River and in the tributaries of New River and Canyon Creek (BLM 1995).

Adult summer-run steelhead enter the Trinity River from April through September and over-summer in deep pools within the mainstem. Some enter the smaller tributary streams of the Trinity River during the first November rains (Hill 2010), with most fish spawning in both the mainstem and tributaries from February through April (USFWS et al. 2004). Summer-run steelhead spawner escapements for the Trinity River upstream of Lewiston Dam prior to its construction were estimated to average 8,000 adults annually. Post-dam survey (reported in 2004) ranged from 20 to 1,037 adult summer steelhead in the tributaries and Trinity River (USFWS et al. 2004).

Juvenile summer-run steelhead may rear in fresh water for up to three years before outmigrating. Rearing in the Trinity River is highly variable, but most summer-run steelhead either outmigrate as young-of-the-year (YOY) or at age 1+ (Scheiff et al. 2001, Pinnix and Quinn 2009, Pinnix et al. 2013). For juveniles that rear at least a year in fresh water, survival appears to be higher for those that outmigrate to the ocean at age 2+ (DFG 1998a). Juveniles outmigrating from the tributaries as 0+ or age 1+ may rear in the mainstem or in nonnatal tributaries (particularly during periods of poor water quality) for one or more years before smolting. Juvenile outmigration can occur from spring through fall, with three peak migration periods including March, May/June, and October/November (USFWS et al. 2004).

Fall-run and winter-run steelhead also are widely distributed throughout the Trinity River. Adult fall-run steelhead enter the Klamath River system in September and October (Hill 2010) and likely spawn in tributaries such as the Trinity River from January through April. Adult winter-run steelhead begin their upstream migration in the Klamath River from November through March (USFWS 1997). Winter-run steelhead primarily spawn in Klamath River tributaries (including the Trinity River) from January through April (USFWS 1997), with peak spawn timing in February and March (NRC 2004).

An estimated run-size of 16,594 adult fall-run steelhead migrated into the Trinity River upstream of Willow Creek in 2013, including the 2,375 fish (80 natural-origin and 2,295 hatchery-origin) that entered the Trinity River Hatchery and 13,560 natural area spawners (9,039 of natural origin and 4,521 of hatchery origin) (CDFW 2014). Since 1980, run-size estimates have ranged from 2,972 in 1998 to 53,885 in 2007. The estimated abundance of steelhead in 2013 was 8.4 percent above the average since 1980 (CDFW 2014).

Green Sturgeon

Limited Green Sturgeon data has been collected in the Trinity River, so most information on life history characteristics for Green Sturgeon in the Trinity River is based on data from the Klamath River. Green Sturgeon in the Klamath River sampled during their spawning migration ranged in age from 16 to 40 years (Van Eenennaam et al. 2006). Green Sturgeon are generally believed to have a life span of at least 50 years and spawn every four years on average after around age 16 (Klimley et al. 2007). Green Sturgeon enter the Trinity and Klamath rivers to spawn from February through July, and most spawning occurs from the middle of April to the middle of June (NRC 2004). After spawning, around 25 percent of Green Sturgeon migrate directly back to the ocean (Benson et al. 2007), and the remainder hold in mainstem pools through November. During the onset of fall rainstorms and increased river flow, adult sturgeon move downstream and leave the river system (Benson et al. 2007). Juvenile Green Sturgeon may rear for one to three years in the Klamath River system before they migrate to the estuary and Pacific Ocean (NRC 2004, FERC 2007a, CALFED 2007), usually during summer and fall (Emmett et al. 1991, Hardy and Addley 2001).

In the Trinity River Basin, Green Sturgeon are known to spawn in the mainstem from the confluence with the Klamath to as far upstream as Gray’s Falls near Burnt Ranch. Juveniles are captured in rotary screw traps at Willow Creek on the Trinity River (Scheiff et al. 2001, Pinnix and Quinn 2009).

White Sturgeon

White Sturgeon are uncommon in the Klamath and Trinity rivers and spawning may not occur (NRC 2004). Historically there may have been small spawning runs in these rivers; almost all of the sturgeon occurring above the Klamath estuary are Green Sturgeon (Moyle 2002).

Pacific Lamprey

Pacific Lamprey are the only anadromous lamprey species in the Trinity River Basin. This species is important to local tribes and supports a subsistence fishery on the lower Trinity River. Although no systematic distribution surveys are available for the Trinity River Basin, they are expected to have a distribution similar to anadromous salmonids that use the mainstem Trinity River and accessible reaches of larger tributaries. No current status assessments are available for Pacific Lamprey in the Trinity River, but information from tribal fishermen who catch lampreys in the lower Klamath River suggests a decline that mirrors that observed across the species’ range (Petersen Lewis 2009).

Adult Pacific Lampreys have been documented entering the Klamath River from the ocean during all months of the year, with peak upstream migration to holding areas from December through June (Larson and Belchik 1998, Petersen Lewis 2009). Migration up the Trinity River is expected to begin slightly later. After entering fresh water as sexually immature adults and undergoing an initial migration, Pacific Lampreys hold through summer and most of winter before spawning the following spring when they reach sexual maturity (Robinson and Bayer 2005, Clemens et al. 2012). After the holding period, individuals undergo a secondary migration in the late winter or early spring from holding areas to spawning grounds (Robinson and Bayer 2005, Clemens et al. 2012, Lampman 2011). Thus, adult Pacific Lampreys with varying levels of sexual maturity may be in the Trinity River throughout the year. Ammocoetes (the larval stage of lamprey) inhabit fine substrates in depositional areas, rearing in the Trinity River and tributaries year-round for up to 7 years before outmigrating to the ocean (Moyle 2002, Reclamation and Trinity County 2006).

Little information is available on factors that influence populations of Pacific Lamprey in the Trinity River, but they are affected by many of the same factors as salmon and steelhead, because of parallels in their life cycles. Lack of access to historical spawning habitats caused by the mainstem dams and other migration barriers, modification of spawning and rearing habitat because of downstream impacts from dams, altered hydrology, and predation by nonnative invasive species such as Brown Trout have likely contributed to adverse effects on the Trinity River Pacific Lamprey population.

American Shad

American Shad, an introduced, anadromous fish, has become established in the Klamath and Trinity rivers. American Shad occur in the lowermost portions of the Trinity River, but are primarily found in the lower Klamath River. Adult fish enter estuaries or streams in late spring or early summer and spawn soon afterward in fresh water. Juvenile shad have been captured regularly in the rotary-screw traps at the Pear Tree and Willow Creek sites during salmonid outmigrant monitoring (Scheiff et al. 2001, Pinnix and Quinn 2009, Pinnix et al. 2013). Sport fishing for American Shad occurs seasonally throughout the lower Trinity River.

9.3.3.2.2 Hatcheries on the Trinity River

The Trinity River Hatchery is located immediately downstream of Lewiston Dam, and is operated by CDFW and funded by Reclamation to mitigate the loss of salmonid production upstream of Lewiston Dam resulting from the Trinity Dam (Reclamation 2008a). The hatchery produces Coho Salmon, fall-run Chinook Salmon, spring-run Chinook Salmon, and steelhead. The hatchery’s Coho Salmon program currently uses only endemic Coho Salmon broodstock and releases approximately 500,000 yearlings annually from March 15 to May 15. The fall-run Chinook Salmon program has a goal of releasing two million sub-yearlings in June and 900,000 yearlings in October from in-river broodstock, and the spring-run Chinook Salmon program has a goal of releasing one million subyearlings in June and 400,000 yearlings in October from in-river broodstock. The steelhead program currently uses only in-river broodstock with a goal to release 800,000 steelhead smolts (approximately six inches) from March 15 to May 1.

9.3.3.3 Lower Klamath River from Trinity River to Pacific Ocean

The Lower Klamath River begins where the Trinity River flows into it near Weitchpec, which is located about 43 miles upstream from the Pacific Ocean. The Trinity River is the largest tributary of the Klamath River and makes a substantial contribution to the flows in the lower Klamath River. This section of the Klamath River serves primarily as a migration corridor for salmonids, with most spawning and rearing upstream of the confluence with the Trinity River or in the larger tributaries (e.g., Blue Creek) to the mainstem Klamath River.

9.3.3.3.1 Fish in the Lower Klamath River

Focal fish species that occur in the lower Klamath River downstream of the Trinity River confluence are included for analysis in this EIS and include all those found in the Trinity River, as described above, with the exception of Eulachon.

Eulachon is a smelt species in the Klamath River system found upstream of the estuary. Eulachon are anadromous broadcast spawners that spawn in the lower reaches of rivers and tributaries and usually die after spawning. Eulachon are sexually mature at 2 years and spawn at ages 3, 4, and/or 5 (Scott and Crossman 1973). Timing of the spawning migration in the Klamath River is similar to other known runs of Eulachon, beginning in December and continuing until May, with a peak in March and April (YTFP 1998, Larson and Belchik 1998).

In the Klamath River, adult Eulachon generally migrate as high as Brooks Riffle, about 40 kilometers (about 24 miles) upstream of the mouth, but have been observed as high as Pecwan Creek and even Weitchpec during exceptional years (YTFP 1998); specific spawning areas are unknown. Eggs hatch in 20 to 40 days depending on water temperature, taking longer at cooler temperatures. After hatching, the larvae are passively carried from spawning grounds to the ocean via river currents (Scott and Crossman 1973).

This species was historically important to local tribes and supported a subsistence fishery on the lower Klamath River. According to accounts of Yurok Tribal elders, there were annual runs so great that one had no problem catching “as many as you wanted;” however, the last noticeable runs of Eulachon were observed in 1988 and 1989 by Tribal fishers (Larson and Belchik 1998). In 1996, YTFP sampling efforts to capture Eulachon were unsuccessful, although a Yurok Tribal member gave the YTFP a Eulachon he had caught while fishing for lamprey at the mouth of the river (Larson and Belchik 1998). However, it is likely that the Eulachon has been extirpated or nearly so on the lower Klamath River (NMFS 2015).

9.3.4 Central Valley Region

Fish and aquatic resources in the Central Valley Region are described in this section in accordance with the following major waterbodies.

- Shasta Lake and Keswick Reservoir
- Whiskeytown Lake
- Clear Creek

- Sacramento River from Keswick Reservoir to the Delta (near Freeport)
- Battle Creek
- Feather River
- Yuba and Bear Rivers
- American River
- Delta
- Yolo Bypass
- Millerton Lake
- San Joaquin River from the Stanislaus River confluence to the Delta (near Vernalis)
- New Melones Reservoir, Tulloch Reservoir, and the reservoir formed by Goodwin Dam
- Stanislaus River
- San Luis Reservoir

9.3.4.1 Shasta Lake and Keswick Reservoir

Shasta Lake is formed by Shasta Dam, which is located on the Sacramento River just downstream of the confluence of the Sacramento, McCloud, and Pit rivers. Shasta Dam has no fish passage facilities; however, the dam has a fish trapping facility that operates in conjunction with Livingston Stone National Fish Hatchery below Shasta Dam.

9.3.4.1.1 Shasta Lake

Shasta Lake fish species include native and introduced warm-water and cold-water species. Major nonfish aquatic animal species assemblages in Shasta Lake include benthic macroinvertebrates and zooplankton (Reclamation 2013b). Shasta Lake is typically thermally stratified from April through November, during which time the upper layer (epilimnion) can reach a peak water temperature of 80 degrees Fahrenheit (°F) (Reclamation 2003). The upper layer of Shasta Lake supports warm-water game fish, and the lower layers (metalimnion and hypolimnion) support cold-water fishes. Nonnative, warm-water fish species in Shasta Lake include Smallmouth Bass, Largemouth Bass, Spotted Bass, Black Crappie, Bluegill, Green Sunfish, Channel Catfish, White Catfish, and Brown Bullhead (DWR et al. 2013). Cold-water species include Rainbow Trout, Brown Trout, landlocked White Sturgeon, landlocked Coho Salmon (Reclamation et al. 2003), and landlocked Chinook Salmon (Reclamation 2013). Other fish species in Shasta Lake include Golden Shiner, Threadfin Shad, Common Carp, and the native Hardhead, Sacramento Sucker, and Sacramento Pikeminnow (DWR et al. 2013, Reclamation 2013).

Water quality in Shasta Lake is generally considered good, largely because of the continual inflow of cool, high-quality water from the major tributaries to the lake. The primary water quality concerns in the lake is turbidity, typically associated with heavy rainfall events that move soils and runoff from abandoned mines in the area into the lake.

Warm-water fish habitat in Shasta Lake is influenced primarily by fluctuations in the lake level and the availability of shoreline cover (Reclamation 2003). Water surface elevations in Shasta Lake can fluctuate approximately 55 feet annually as a result of operation of Shasta and Sacramento River diversions (Reclamation 2003). Reservoir surface elevation fluctuations can disturb shallow, nearshore habitats, including spawning and rearing habitat for warm-water fish species. The shoreline of Shasta Lake is generally steep, which limits shallow, warm-water fish habitat, and is not conducive to the establishment of vegetation or other shoreline cover (Reclamation 2003).

9.3.4.1.2 Keswick Reservoir

Keswick Reservoir is a re-regulating reservoir for Shasta Lake. The water surface elevation is relatively constant. Residence time for water in Keswick Reservoir is about a day, compared with a residence time of about a year for water in Shasta Lake. Consequently, water temperatures tend to be controlled by releases from Shasta Dam and average less than 55°F. Despite the cool temperatures, the reservoir supports warm-water and cold-water fishes, including Largemouth Bass, crappie and catfish, and Rainbow Trout (Reclamation 2003).

9.3.4.2 Whiskeytown Lake

Water is diverted from the Trinity River at Lewiston Dam and discharged via the Clear Creek Tunnel into Whiskeytown Lake on Clear Creek. From Whiskeytown Lake, water is released into the lower portion of Clear Creek via Whiskeytown Dam and into Keswick Reservoir through the Spring Creek Tunnel. There are two temperature control curtains in Whiskeytown Lake: Oak Bottom and Spring Creek (Reclamation 2008a). The Oak Bottom temperature control curtain serves as a barrier to prevent warm water in the reservoir from mixing with cold water from Lewiston Lake entering through the Carr Powerhouse. The Oak Bottom curtain is damaged and cannot be fully deployed; it is scheduled to be repaired in 2015. The Spring Creek temperature control curtain was replaced in 2011 and aids cold-water movement into the underwater intake for the Spring Creek Tunnel.

The fish assemblage in Whiskeytown Lake includes cold-water and warm-water species. Common fishes known to occur in Whiskeytown Lake include Rainbow Trout, Brown Trout, Kokanee Salmon, Largemouth Bass, crappie, sunfish, catfish, and bullhead (USFWS et al. 2004).

9.3.4.3 Clear Creek

The project area includes the reach of Clear Creek extending from Whiskeytown Dam to the confluence with the Sacramento River. Since 1995, extensive habitat and flow restoration in Clear Creek has occurred under the Central Valley Project

Improvement Act (CVPIA) and CALFED programs and in accordance with the NMFS 2009 BO. The Clear Creek Technical Team has been working since 1996 to facilitate implementation of CVPIA anadromous salmonid restoration actions (Brown et al. 2012). Restoration efforts have resulted in increased stocks of fall-run Chinook Salmon and re-established populations of spring-run Chinook Salmon and steelhead.

9.3.4.3.1 Fish in Clear Creek

This analysis is focused on Chinook Salmon, steelhead, and Pacific Lamprey in Clear Creek.

Spring-run Chinook Salmon

Clear Creek currently supports a modest run of spring-run Chinook Salmon, which since 1998 has ranged from 0 in 2001 to an estimated high of 659 fish in 2013 (CDFW 2014). Adult spring-run Chinook Salmon migrate into Clear Creek from April through September. Adult fish tend to move as far upstream as possible to access cooler temperatures downstream of Whiskeytown Dam and hold over in summer until spawning in September through October. In the NMFS 2009 BO, NMFS expressed concern that spring-run Chinook Salmon unable to enter Clear Creek for spawning could hybridize with fall-run Chinook Salmon spawning in the Sacramento River (NMFS 2009a).

NMFS (2009a) reported that insufficient instream flows could fail to attract adult spring-run holding in the Sacramento River mainstem into Clear Creek. Adult spring-run Chinook Salmon tend to spread downstream of their holding areas prior to spawning (from Whiskeytown Dam downstream to the Clear Creek Road Bridge) from September through October. Egg incubation occurs from September through December, and juveniles rear from October through April (NMFS 2009a).

Spawning gravel is annually augmented in Clear Creek downstream of Whiskeytown Dam under the CVPIA Clear Creek Restoration Program and in accordance with the 2009 NMFS BO (Reclamation 2013a). Additionally, water temperature criteria to protect spring-run Chinook Salmon during spawning and incubation are generally met; however, in recent years, water temperatures in Clear Creek during the spawning and incubation period (i.e., September 15 to October 31) have exceeded the temperature targets at times (Brown et al. 2012).

Based on rotary screw trap captures, juvenile spring-run Chinook Salmon outmigrate from Clear Creek from May through February. Peak outmigration occurs over a 9-week period from early December 2008 through early February 2009 (Earley et al. 2010). Trap data indicate that the majority of juveniles identified as spring-run (based on length-at-date size criteria) leave as age-0 fish, less than 40 millimeter (mm) in fork length (USFWS 2008b, Earley et al. 2010).

Fall-/Late Fall-run Chinook Salmon

Since 1995, restoration activities implemented in accordance with programs implemented under the CVPIA, CALFED, and the 2009 NMFS BO have increased stocks of fall-run Chinook Salmon by more than 400 percent (Brown

2011). In 2014, fall-run Chinook Salmon estimated escapement was 15,794 compared to the average baseline (1967-1991) estimated escapement of 1,689.

Fall/late fall-run Chinook Salmon primarily use the lower reaches of Clear Creek for all life history phases. Fall-run Chinook migrate into Clear Creek between the spring- and late fall-runs and spawn in October through December (USFWS 2015). A picket weir installed about 7.4 miles upstream of the confluence with the Sacramento River from August 1 to November 1 is used to prevent fall-run Chinook Salmon from spawning in the upper reaches with spring-run.

Late-fall-run Chinook Salmon migrate into Clear Creek from November through April, with peak migration in December; peak spawning occurs in January.

Based on rotary screw trap captures and length-at-date size criteria, fall-run Chinook Salmon make up the vast majority of all Chinook Salmon outmigrating from lower Clear Creek. Late fall-run juveniles constitute a small percentage of juvenile Chinook Salmon leaving Clear Creek. Juvenile fall-/late fall-run Chinook Salmon primarily outmigrate from Clear Creek as age-0 fish less than 40 mm in fork length (USFWS 2008b, Earley et al. 2010). Peak age-0 outmigration in 2008/2009 was from January and February for fall-run Chinook Salmon and during April to May for late fall-run Chinook Salmon (Earley et al. 2010).

Steelhead

Operation of Whiskeytown Dam supports cold-water habitat for steelhead in Clear Creek, the amount of which depends on flow releases which range from 30 to 200 cubic feet per second (cfs) depending on water year type (Reclamation 2008a). Steelhead have recolonized the habitat that became accessible with the removal of the McCormick-Saeltzer Dam in 2000. Redd surveys conducted since 2003 indicate that a small, but increasing population of steelhead resides in Clear Creek, with the highest density in the first mile below Whiskeytown Dam (USFWS 2007).

Adult steelhead immigration into Clear Creek usually occurs from August through March, with a peak occurring from September to November (USFWS 2008b). Adult steelhead tend to hold in the upper reaches of Clear Creek from September to December.

Spawning typically begins in December and continues through early March. Peak spawning occurs from late January to early February (USFWS 2007). The embryo incubation life stage begins with the onset of spawning in late December and generally extends through April.

Spawning distribution has recently expanded from the upper 4 miles of lower Clear Creek to the entire 17 miles of lower Clear Creek, although it appears to be concentrated in areas of newly added spawning gravels. Recently, more steelhead were observed spawning in the lowest reach of the creek where resulting juveniles can be subject to warmer water temperatures during summer (Brown 2011).

Summertime water temperatures are often critical for steelhead rearing and limit rearing habitat quality in many streams. Instream flow releases are intended to maintain suitable water temperatures throughout most of Clear Creek during summer. Snorkel surveys from 1999 to 2002 indicate that rearing steelhead may be present throughout all of lower Clear Creek (Good et al. 2005). Based on rotary screw trap captures, fry make up the vast majority of all steelhead/Rainbow Trout captured in lower Clear Creek. Peak outmigration of juvenile steelhead fry occurred from mid-March through April of 2009 (Earley et al. 2010).

Pacific Lamprey

Pacific Lamprey is expected to inhabit all reaches in Clear Creek upstream to Whiskeytown Dam. The loss of access to historical habitat and apparent population declines throughout California and the Sacramento and San Joaquin River basins indicate the population is likely reduced compared with historical levels (Moyle et al. 2009). Little information is available on factors influencing populations of Pacific Lamprey in Clear Creek, but they are likely affected by many of the same factors as salmon and steelhead because of parallels in their life cycles.

Ocean stage adult Pacific Lampreys likely migrate into Clear Creek in summer, where they hold for approximately 1 year before spawning (Hanni et al. 2006). No information is available on spawning in Clear Creek; however, spawning period documented by Hannon and Deason (2008) for Pacific Lampreys in the American River of early January to late May, with peak spawning typically in early April, may also apply to Clear Creek. Pacific Lamprey ammocoetes rear in Clear Creek for all or part of their 5- to 7-year freshwater residence. Data from rotary screw trapping in Clear Creek suggest that some outmigration of Pacific Lampreys may occur year-round, but peak outmigration occurs from early winter through spring (Hanni et al. 2006).

9.3.4.3.2 Extent and Status of Aquatic Habitat

Whiskeytown Dam limits the contribution of coarse sediment for transport downstream in Clear Creek, which NMFS (2009a) reported has resulted in riffle coarsening, fossilization of alluvial features, loss of fine sediments available for overbank deposition, and considerable loss of spawning gravels. These conditions affect spawning and rearing habitat on Clear Creek. Water flows and temperatures conditions on Clear Creek are presented in Chapter 5, Surface Water Resources and Water Supplies, and Chapter 6, Surface Water Quality, respectively.

Spawning Habitat

An unpublished study conducted by USFWS (as cited in Brown 2011) suggested that gravel transport blocked by the construction of Whiskeytown Dam reduced spawning habitat in Clear Creek by 92 percent. Plans developed under CVPIA implementation included a goal to create and maintain 347,288 square feet of usable spawning habitat between Whiskeytown Dam to the former McCormick-Saeltzer Dam by 2020. This area is equivalent to the spawning habitat that existed before construction of Whiskeytown Dam (CVPIA 2014).

Brown (2011) noted that much of the degraded habitat has been restored by gravel augmentation, but continued augmentation will be required. Spawning gravel is annually augmented in Clear Creek downstream of Whiskeytown Dam, pursuant to CVPIA implementation and Action of I.1.3 of the 2009 NMFS BO Reasonable and Prudent Alternative (RPA). The CVPIA annual spawning gravel target is 25,000 tons per year; however, an average of 9,574 tons has been placed annually since 1996. In 2012, a total of 9,974 tons of gravel was placed at four sites: Guardian Rock site, Placer Bridge, Clear Creek Road Crossing, and at Tule Backwater. A gravel injection project did not occur in 2013 (CVPIA 2014).

Most supplemental spawning gravel is placed into Clear Creek at long-term injection sites awaiting high flows to move gravel into the creek. These gravel addition projects have successfully created habitat suitable for spring-run Chinook Salmon spawning as evidenced by the number of redds directly observed in supplemental gravel or in supplemental gravel integrated into native gravel (USFWS 2007, 2008b). Spawning area mapping performed annually since 2000 indicates the overall amount of area used by spawning fall-run Chinook Salmon has been increasing, despite the adult population abundance remaining stable. The amount of area used in 2008 was the highest measured and more than double the amount used in 2000, suggesting that the gravel augmentation program has been successful in creating new spawning habitat. Gravel augmentation also has increased the amount of steelhead spawning habitat available in the lower reaches of Clear Creek, and NMFS (2009a) has indicated that this directly relates to higher fish abundance in recent years. In most locations, gravel additions created spawning habitat that did not exist or had limited prior use.

Studies to determine the availability of fish habitat, expressed as Weighted Useable Area (WUA), have been conducted by USFWS for Clear Creek (USFWS 2006). For spring-run Chinook Salmon, it was determined that spawning WUA peaked at the highest modeled flow (900 cfs) in the upstream alluvial segment from Whiskeytown Dam to the NEED Camp Bridge. In the canyon segment downstream (NEED Camp Bridge to the Clear Creek Road Bridge) spawning habitat peaked at 650 cfs. The WUA for steelhead/Rainbow Trout spawning habitat peaked at 350 cfs and 600 cfs in these segments, respectively (USFWS 2007). In the lower reach downstream of the Clear Creek Road Bridge, WUA for both fall-run Chinook Salmon and steelhead/Rainbow Trout spawning habitat peaked at 300 cfs (USFWS 2011a).

At all flows, the amount of spawning habitat present in Clear Creek is less than the amount needed to achieve the abundance recovery goal of spring-run Chinook Salmon spawning (based on the original USFWS [2007] estimates). However, the increased spawning habitat availability due to gravel additions since 2003 suggests that spawning habitat for spring-run Chinook Salmon is now more than sufficient to support the recovery goal at all flows. At flows greater than 50 cfs, the amount of spawning habitat present in Clear Creek is greater than the amount of spawning habitat needed to achieve the abundance recovery goal for steelhead. In contrast, the amount of spawning habitat present in Clear Creek is less than the amount of spawning habitat needed to support 7,920 adult fall-run Chinook Salmon in Clear Creek (USFWS 2015).

Rearing Habitat

The WUA for spring-run Chinook Salmon fry rearing peaked at 600 cfs in the upstream alluvial segment from Whiskeytown Dam to the NEED Camp Bridge. In the canyon segment downstream (NEED Camp Bridge to Clear Creek Road Bridge), fry rearing habitat peaked at the highest modeled flow (900 cfs). The WUA for steelhead/Rainbow Trout fry rearing habitat peaked at 700 cfs and 900 cfs (the maximum flow modeled) in these segments, respectively (USFWS 2011b). The WUA for spring-run Chinook Salmon and steelhead/Rainbow Trout juvenile rearing habitat peaked at the highest modeled flow (900 cfs) in the upper alluvial segment and 650 cfs in the canyon segment downstream. In the lower reach downstream of the Clear Creek Road Bridge, WUA for both fall-run Chinook Salmon and steelhead/Rainbow Trout fry rearing habitat peaked at 50 cfs; fry rearing habitat for spring-run Chinook Salmon peaked at 900 cfs. Spring-run Chinook Salmon and steelhead/Rainbow Trout juvenile rearing habitat peaked at 850 cfs, while fall-run Chinook Salmon juvenile rearing habitat peaked at 350 cfs (USFWS 2013a).

As described above for spawning habitat, USFWS (2015) compared the total amount or rearing habitat available for spring-run Chinook Salmon and steelhead/Rainbow Trout to the amount of rearing habitat needed to support an annual escapement of 833 adults for each species. The total amount of rearing habitat available for fall-run Chinook Salmon was compared to the amount of habitat needed to support an average escapement of 7,920 fall-run Chinook Salmon. At all flows, the amount of rearing habitat present in Clear Creek is greater than the amount needed to achieve the abundance recovery goal for spring-run Chinook Salmon and steelhead. In contrast, the amount of rearing habitat present in Clear Creek is less than the amount needed to support 7,920 adult fall-run Chinook Salmon in Clear Creek.

9.3.4.3.3 Fish Passage

Whiskeytown Dam blocks access to 25 miles of historical spring-run Chinook Salmon and steelhead spawning and rearing habitat (Yoshiyama et al. 1996). Until 2000, the McCormick-Saeltzer Dam was a barrier to upstream migration for anadromous salmonids. After its removal, anadromous salmonids recolonized an additional 12 miles of habitat upstream to Whiskeytown Dam. With the removal of McCormick-Saeltzer Dam, passage of spring-run Chinook Salmon has increased. Stream surveys and juvenile monitoring results also suggest that dam removal has allowed reestablishment of spring-run Chinook Salmon and steelhead. NMFS (2009a) reported that compared to fall-run Chinook Salmon, spring-run Chinook Salmon historically spawned earlier and at locations farther upstream in Clear Creek. However, NMFS (2009a) concluded that the construction of Whiskeytown Dam likely caused a high degree of spatial overlap between the fall-run and spring-run fish during spawning, resulting in a higher probability of hybridization. To address this concern, USFWS has been separating adult fall-run fish from the spring-run fish holding in the upper reaches of Clear Creek with a segregation weir that is operated from August 1 to November 1. After November 1, fall-run Chinook Salmon have access to the entire river for spawning.

9.3.4.4 Sacramento River from Keswick Reservoir to the Delta near Freeport

Aquatic resources in the Sacramento River are affected by the habitat along the river and along the tributaries that connect to the river. Habitat along the river ranges from artificial structures used for water supply and flood management to open spaces that provide more natural types of habitat. The flow regime in the Sacramento River is managed for water supply and flood management, as described in Chapter 5, Surface Water Resources and Water Supplies. The following discussion focuses on the fish in the Sacramento River and aquatic habitat conditions.

9.3.4.4.1 Fish in the Sacramento River

The analysis is focused on the following species:

- Chinook Salmon (winter-, spring-, and fall/late fall-run)
- Steelhead
- Green Sturgeon
- White Sturgeon
- Sacramento Splittail
- Pacific Lamprey
- Striped Bass
- American Shad

Winter-run Chinook Salmon

Adult winter-run Chinook Salmon return to fresh water during winter but delay spawning until spring and summer. Adults enter fresh water in an immature reproductive state, similar to spring-run Chinook, but winter-run Chinook move upstream much more quickly and then hold in the cool waters downstream of Keswick Dam for an extended period before spawning. Juveniles spend about 5 to 9 months in the river and estuary systems before entering the ocean. This life-history pattern differentiates the winter-run Chinook from other Sacramento River Chinook runs and from all other populations within the range of Chinook Salmon (DFG 1985, 1998b).

Access to approximately 58 percent of the original winter-run Chinook Salmon habitat has been blocked by dam construction (Reclamation 2008a). The remaining accessible habitat occurs in the Sacramento River downstream of Keswick Dam and in Battle Creek. The number of winter-run Chinook Salmon in Battle Creek is unknown, but if they do occur, they are scarce (Reclamation and SWRCB 2003).

Escapement data indicate that the winter-run Chinook Salmon population declined from its levels in the 1970s to relatively low levels through the 1980s and 1990s, with a small rebound in the early 2000s (Azat 2012).

Adult winter-run Chinook Salmon migrate upstream past the location of the Red Bluff Diversion Dam (RBDD) beginning in mid-December and continuing into early August. Most of the run passes RBDD between January and May, with the peak in mid-March (DFG 1985). Winter-run Chinook Salmon spawn only in the Sacramento River, almost exclusively above RBDD, with the majority spawning upstream of Balls Ferry, based on aerial redd survey data collected after passage was provided past the Anderson-Cottonwood Irrigation District (ACID) diversion. Aerial redd surveys have indicated that the winter-run Chinook Salmon spawning distribution has shifted upstream since gravel introductions began in the upper river near Keswick Dam; a high proportion of winter run Chinook spawn on the recently placed gravel (USFWS and Reclamation 2008). Spawning occurs May through July, with the peak in early June. Fry emergence occurs from mid-June through mid-October and fry disperse to areas downstream for rearing. Juvenile migration past RBDD may begin in late July, generally peaks in September, and can continue until mid-March in drier years (Vogel and Marine 1991). The majority (75 percent) of winter-run Chinook Salmon outmigrate past RBDD as fry (Martin et al. 2001), where they rear before outmigrating to the Delta primarily in December through April (Appendix 9B). Between 44 and 81 percent (mean 65 percent) of juvenile winter-run Chinook Salmon used areas downstream of RBDD for nursery habitat, and the relative usage of rearing habitat upstream and downstream of RBDD appeared to be influenced by river flow during fry emergence (Martin et al. 2001). Winter-run Chinook Salmon usually migrate past Knight’s Landing once flows at Wilkins Slough rise to about 14,000 cfs; most juvenile winter-run Chinook Salmon outmigrate past Chipps Island by the end of March (del Rosario et al. 2013).

Spring-run Chinook Salmon

Historically, spring-run Chinook Salmon in the Sacramento River Basin were found in the upper and middle reaches (1,000 to 6,000 feet) of the American, Yuba, Feather, Sacramento, McCloud and Pit rivers, as well as smaller tributaries of the upper Sacramento River downstream of present-day Shasta Dam (NMFS 2009a). Estimates indicate that 82 percent of the approximately 2,000 miles of salmon spawning and rearing habitat available in the mid-1800s is unavailable or inaccessible today (Yoshiyama et al. 1996). Naturally spawning populations of spring-run Chinook Salmon currently are restricted to accessible reaches of the upper Sacramento River, Antelope Creek, Battle Creek, Beegum Creek, Big Chico Creek, Butte Creek, Clear Creek, Deer Creek, Feather River, Mill Creek, and Yuba River (DFG 1998b). Most of these reaches are outside the project area; however, all spring-run Chinook Salmon migratory life stages must pass through the project area.

Spring-run Chinook Salmon abundance in the Sacramento River mainstem has apparently declined sharply through time, with escapement estimates ranging from approximately 5,000 to 23,000 fish in the 1980s, 100 to 4,100 fish in the

1990s, and 0 to 621 fish between 2000 and 2014 (CDFW 2015). However, the criteria for run classification at RBDD have changed so no conclusions can be reached about changes in the number of spring-run Chinook Salmon in the Sacramento River. Chinook Salmon expressing spring-run timing do spawn in the mainstem Sacramento River between RBDD and Keswick Dam (NMFS 2009a). The Sacramento River now serves primarily as a migratory corridor for the adult and juvenile life stages of spring-run (and other runs) of Chinook Salmon.

In fresh water, juvenile spring-run Chinook Salmon rear in natal tributaries, the Sacramento River mainstem, and nonnatal tributaries to the Sacramento River (DFG 1998b). Outmigration timing is highly variable, as they may migrate downstream as YOY or as juveniles or yearlings. The outmigration period for spring-run Chinook Salmon extends from November to early May, with up to 69 percent of the YOY fish outmigrating through the lower Sacramento River and Delta during this period (DFG 1998b). Peak movement of juvenile spring-run Chinook Salmon in the Sacramento River at Knights Landing occurs in December and again in March (Snider and Titus 1998, 2000b, c, d; Vincik et al. 2006; Roberts 2007). Migratory cues, such as increased flows, increasing turbidity from runoff, changes in day length, or intraspecific competition from other fish in their natal streams, may spur outmigration of juveniles from the upper Sacramento River basin when they have reached the appropriate stage of maturation (NMFS 2009a). Spring-run juveniles that remain in the Sacramento River over summer are confined to approximately 100 miles of the upper mainstem, where cool water temperatures are maintained by dam releases.

Fall-/Late Fall-run Chinook Salmon

The fall-run Chinook Salmon is an ocean-maturing type of salmon adapted for spawning in lowland reaches of big rivers, including the mainstem Sacramento River; the late fall-run Chinook Salmon is mostly a stream-maturing type (Moyle 2002). Similar to spring-run, adult late fall-run Chinook Salmon typically hold in the river for 1 to 3 months before spawning, while fall-run Chinook Salmon generally spawn shortly after entering fresh water. Fall-run Chinook Salmon migrate upstream past RBDD on the Sacramento River between July and December, typically spawning in upstream reaches from October through March. Late fall-run Chinook Salmon migrate upstream past RBDD from August to March and spawn from January to April (NMFS 2009a, TCCA 2008). The majority of young fall-run Chinook Salmon migrate to the ocean during the first few months following emergence, although some may remain in fresh water and migrate as yearlings. Late fall-run juveniles typically enter the ocean after 7 to 13 months of rearing in fresh water, at 150- to 170 mm in fork length, considerably larger and older than fall-run Chinook Salmon (Moyle 2002).

The primary spawning area used by fall- and late fall-run Chinook Salmon in the Sacramento River is the area from Keswick Dam downstream to RBDD. Spawning densities for each of the runs are generally highest in this reach.

Annual fall-run and late fall-run Chinook Salmon escapement to the Sacramento River and its tributaries has generally been declining in the last decade, following peaks in the late 1990s to early 2000s (Azat 2012).

Steelhead

Although steelhead can be divided into two life history types, summer-run steelhead and winter-run steelhead, based on their state of sexual maturity at the time of river entry, only winter-run steelhead are currently found in Central Valley rivers and streams. Existing wild steelhead stocks in the Central Valley are mostly confined to the upper Sacramento River and its tributaries, including Antelope, Deer, and Mill creeks and the Yuba River. Populations may exist in other tributaries, and a few naturally spawning steelhead are produced in the American and Feather rivers (McEwan and Jackson 1996).

Adult steelhead migrate upstream past the Fremont Weir between August and March, primarily from August through October; they migrate upstream past RBDD during all months of the year, but primarily during September and October (NMFS 2009a). The primary spawning area used by steelhead in the Sacramento River is the area from Keswick Dam downstream to RBDD. Unlike salmon, steelhead may live to spawn more than once and generally rear in freshwater streams for 2 to 4 years before outmigrating to the ocean. Both spawning areas and migratory corridors are used by juvenile steelhead for rearing prior to outmigration. The Sacramento River functions primarily as a migration channel, although some rearing habitat remains in areas with setback levees (primarily upstream of Colusa) and flood bypasses (e.g., Yolo Bypass) (NMFS 2009a).

Recent steelhead monitoring data are scarce for the upper portion of the Sacramento River system. In 1989, Hallock (1989) reported that steelhead had declined drastically in the Sacramento River upstream of the Feather River confluence. In the 1950s, the average estimated spawning population size upstream of the Feather River confluence was 20,540 fish (McEwan and Jackson 1996). In 1991–1992, the annual run size for the total Sacramento River system was likely fewer than 10,000 adult fish (McEwan and Jackson 1996). From 1967 to 1993, the estimated number of steelhead passing the Red Bluff Pumping Plant ranged from a low of 470 to a high of 19,615 (CHSRG 2012). Steelhead escapement surveys at the site of RBDD ended in 1993.

Green Sturgeon

The Sacramento River provides habitat for Green Sturgeon spawning, adult holding, foraging, and juvenile rearing. Suitable spawning temperatures and spawning substrate exist for Green Sturgeon in the Sacramento River upstream and downstream of RBDD (Reclamation 2008a). Although the upstream extent of historical Green Sturgeon spawning in the Sacramento River is unknown, the observed distribution of sturgeon eggs, larvae, and juveniles indicates that spawning occurs from Hamilton City to as far upstream as Ink’s Creek confluence and possibly up to the Cow Creek confluence (Brown 2007, Poytress et al. 2013). Based on the distribution of sturgeon eggs, larvae, and juveniles in the Sacramento River, DFG (2002) indicated that Green Sturgeon spawn in late spring and early summer. Peak spawning is believed to occur between April and June.

Spawning migrations and spawning by Green Sturgeon in the Sacramento River mainstem have been well documented over the last 15 years (Beamesderfer et al. 2004). Anglers fishing for White Sturgeon or salmon commonly report catches of Green Sturgeon from the Sacramento River as far upstream as Hamilton City (Beamesderfer et al. 2004). Eggs, larvae, and post-larval Green Sturgeon are now commonly reported in sampling directed at Green Sturgeon and other species (Beamesderfer et al. 2004, Brown 2007). YOY Green Sturgeon have been observed annually since the late 1980s in fish sampling efforts at RBDD and the Glenn-Colusa Irrigation District (GCID) intake (Beamesderfer et al. 2004). Acoustically tagged Green Sturgeon were detected upstream of RBDD from 2004 to 2006 (Heublein et al. 2009). Adult Green Sturgeon that migrate upstream in April, May, and June are completely blocked by the ACID diversion dam (NMFS 2009b), rendering approximately 3 miles of spawning habitat upstream of the diversion dam inaccessible.

Green Sturgeon from the Sacramento River are genetically distinct from their northern counterparts, indicating a spawning fidelity to their natal rivers (Israel et al. 2004), even though individuals can range widely (Lindley et al. 2008). Larval Green Sturgeon have been regularly captured during their dispersal stage at about 2 weeks of age (24 to 34 mm fork length) in rotary screw traps at RBDD (DFG 2002a) and at about 3 weeks old when captured at the GCID intake (Van Eenennaam et al. 2001).

Young Green Sturgeon appear to rear for the first 1 to 2 months in the Sacramento River between Keswick Dam and Hamilton City (DFG 2002a). Rearing habitat condition and function may be affected by variation in annual and seasonal river flow and temperature characteristics.

Empirical estimates of Green Sturgeon abundance are not available for the Sacramento River population or any west coast population (Reclamation 2008a), and the current population status is unknown (Beamesderfer et al. 2007, Adams et al. 2007). A genetic analysis of Green Sturgeon larvae captured in the Sacramento River resulted in an estimate of the number of adult spawning pairs upstream of RBDD ranging from 32 to 124 between 2002 and 2006 (Israel 2006). NMFS (2009b) noted that, similar to winter-run Chinook Salmon, the restriction of spawning habitat for Green Sturgeon to only one reach of the Sacramento River increases the vulnerability of this spawning population to catastrophic events. This was one of the primary reasons that the Southern DPS of Green Sturgeon was federally listed as a threatened species in 2006.

White Sturgeon

In California, White Sturgeon are most abundant within the Delta region, but the population spawns mainly in the Sacramento River; a small part of the population is also thought to spawn in the Feather River (Moyle 2002). In addition to spawning, White Sturgeon embryo development and larval rearing occur in the Sacramento River (Moyle 2002, Israel et al. 2008). White Sturgeon are found in the Sacramento River primarily downstream of RBDD (TCCA 2008), with most spawning between Knights Landing and Colusa (Schaffter 1997).

The population status of White Sturgeon in the Sacramento River is unclear. Overall, limited information on trends in adult and juvenile abundance in the Delta population suggests that numbers are declining (Reis-Santos et al. 2008). Spawning stage adults generally move into the lower reaches of the Sacramento River during winter prior to spawning, then migrate upstream in response to higher flows to spawn from February to early June (Schaffter 1997, McCabe and Tracy 1994). Most spawning in the Sacramento River occurs in April and May (Kohlhorst 1976). YOY White Sturgeon make an active downstream migration that disperses them widely to rearing habitat throughout the lower Sacramento River and Delta (McCabe and Tracy 1994, Israel et al. 2008).

Sacramento Splittail

Historically, Sacramento Splittail were widespread in the Sacramento River from Redding to the Delta (Rutter 1908 as cited in Moyle et al. 2004). This distribution has become somewhat reduced in recent years (Sommer et al. 1997, 2007b). During drier years there is evidence that spawning occurs farther upstream (Feyrer et al. 2005). Adult splittail migrate upstream in the lower Sacramento River to above near the mouth of the Feather River and into the Sutter and Yolo bypasses (Sommer et al. 1997, Feyrer et al. 2005, Sommer et al. 2007b). Each year, mainly during the spring spawning season, a small number of individuals have been documented at the Red Bluff Pumping Plant and the entrance to the GCID intake (Moyle et al. 2004).

Nonreproductive adult splittail are most abundant in moderately shallow, brackish areas, but can also be found in freshwater areas with tidal or riverine flow (Moyle et al. 2004). Adults typically migrate upstream from brackish areas in January and February and spawn in fresh water on inundated floodplains in March and April (Moyle et al. 2004, Sommer et al. 2007b). In the Sacramento drainage, the most important spawning areas appear to be the Yolo and Sutter bypasses; however, some spawning occurs almost every year along the river edges and backwaters created by small increases in flow. Splittail spawn in the Sacramento River from Colusa to Knights Landing in most years (Feyrer et al. 2005).

Most juvenile splittail move from upstream areas downstream into the Delta from April through August (Meng and Moyle 1995, Sommer et al. 2007b). The production of YOY Sacramento Splittail is largely influenced by extent and period of inundation of floodplain spawning habitats, with abundance spiking following wet years and declining after dry years (Sommer et al. 1997, Moyle et al. 2004, Feyrer et al. 2006). Other factors that may affect the Sacramento Splittail adult population include flood control operations and infrastructure, entrainment by irrigation diversion, recreational fishing, changed estuarine hydraulics, pollutants, and nonnative species (Moyle et al. 2004, Sommer et al. 2007b).

Pacific Lamprey

Pacific Lampreys are anadromous, rearing in fresh water before outmigrating to the ocean, where they grow to full size prior to returning to their natal streams to spawn. Data from mid-water trawls in Suisun Bay and the lower Sacramento River indicate that adults likely migrate into the Sacramento River and tributaries from late fall (November) through early-summer (June) (Hanni et al. 2006). Adult Pacific Lampreys, either immature or spawning stage, have been detected at the GCID diversion from December through July and nearly all year at RBDD (Hanni et al. 2006). Hannon and Deason (2008) documented Pacific Lampreys spawning in the American River between early January and late May, with peak spawning typically in early April. Spawning in the Sacramento River is expected to occur during a similar timeframe. Pacific Lamprey ammocoetes rear in parts of the Sacramento River for all or part of their 5- to 7-year freshwater residence. Data from rotary screw trapping at sites on the mainstem Sacramento River indicate that outmigration of Pacific Lamprey peaks from early winter through early summer, but some outmigration is observed year-round at both RBDD and the GCID diversion dam (Hanni et al. 2006).

Striped Bass

Striped Bass are anadromous; adult Striped Bass are distributed mainly in the lower bays and ocean during summer, and in the Delta during fall and winter. Spawning takes place in spring from April to mid-June (Leet et al. 2001) at which time Striped Bass swim upstream to spawning grounds. Striped Bass are not believed to spawn or rear in the Sacramento River upstream of RBDD (TCCA 2008). Most Striped Bass spawning occurs in the lower Sacramento River between Colusa and the confluence of the Sacramento and Feather rivers (Moyle 2002). About one-half to two-thirds of the eggs are spawned in the Sacramento River and the remainder in the Delta (Leet et al. 2001). After spawning, most adult Striped Bass move downstream into brackish and salt water for summer and fall.

Eggs are free-floating and negatively buoyant, hatching as they drift downstream with larvae occurring in shallow and open waters of the lower reaches of the Sacramento and San Joaquin rivers, the Delta, Suisun Bay, Montezuma Slough, and Carquinez Strait. The Sacramento River functions primarily as a migration corridor for both adults and drifting eggs/larvae.

9.3.4.4.2 Aquatic Habitat

The mainstem Sacramento River provides habitat for native and introduced (nonnative) fish and other aquatic species. The diversity of aquatic habitats ranges from fast-water riffles and glides in the upper reaches to tidally influenced slow-water pools and glides in the lower reaches (Vogel 2011).

A few miles downstream of Keswick Dam, near Redding, the river enters the valley and the floodplain broadens. Historically, this area likely had wide expanses of riparian forests, but much of the river’s riparian zone is subject to urban encroachment, particularly in the Anderson/Redding area. In the middle Sacramento River between Red Bluff and Chico Landing, the mainstem channel is flanked by broad floodplains (TNC 2007a). In the lower reaches downstream of Verona, much of the Sacramento River is constrained by levees. Dredging, dams, levee construction, urban encroachment, and other human activities in the Sacramento River have modified aquatic habitat, altered sediment dynamics, simplified stream bank and riparian habitat, reduced floodplain connectivity, and modified hydrology (NMFS 2009a). However, some complex floodplain habitats remain in the system such as reaches with setback levees and the Yolo and Sutter bypasses.

Holding Habitat

An abundance of deep, cold-water pools in the mainstem Sacramento River provide habitat for holding adult anadromous salmonids during all months of the year (Vogel 2011). Green Sturgeon also use deep pools for holding but can tolerate warmer water temperatures than salmon and, therefore, can hold farther downstream. Large numbers of adult Green Sturgeon have been observed holding during summer in deep pools in the Sacramento River near Hamilton City (Vogel 2011).

Spawning Habitat

Spawning habitat on the Sacramento River is affected by lack of sediment and flow patterns as determined by the operations of the CVP and local water diverters.

Sediment Conditions

Shasta and Keswick dams substantially influence sediment transport in the upper Sacramento River because they block sediment that would normally have been transported downstream (TNC 2007a, DWR 1985). The result has been a net loss of coarse sediment, including gravel particle sizes suitable for salmon spawning, in the Sacramento River downstream of Keswick Dam (Reclamation 2013b). To address the issue of spawning gravel loss downstream of Keswick Dam, Reclamation has placed approximately 5,000 tons of washed spawning gravel into the Sacramento River downstream of Keswick about every other year since 1997 (Reclamation 2010a).

Spawning Habitat Availability

Winter-run Chinook Salmon spawning in the upper reaches of the Sacramento River is affected by the operations of the seasonal ACID diversion dam, which involves placement of flashboards in the river between April and May. Flows in the river vary with the operation of the diversion dam and releases of water from Shasta Lake into the river. When the dam is installed in the river, the WUA upstream of the Cow Creek confluence is higher than when the dam is removed. Farther downstream, there is less variability in WUA.

The WUA for winter-run Chinook Salmon spawning peaks at around 10,000 cfs in the upstream reach upstream of the ACID intake when the dam flashboards are in. With the boards out, the peak is around 5,500 cfs. In the next reach downstream (ACID intake to Cow Creek), spawning WUA also peaked at around 10,000 cfs. In the lower reach (Cow Creek to Battle Creek), WUA spawning habitat peaks at around 5,250 cfs, but there is low variability in spawning WUA from 3,250 to 8,000 cfs

Overall, spawning habitat WUA values differ for fall-run and late fall-run Chinook Salmon, but the flow versus habitat relationship is about the same for the two runs. Upstream of the ACID intake, spawning habitat WUA for fall- and late fall-run Chinook Salmon peaks at the lowest flow analyzed (3,250 cfs) with the dam flashboards out and at about 6,000 cfs with the flashboards in. Between the ACID intake and Cow Creek, spawning habitat WUA peaks at around 5,000 cfs for both runs. Between Cow Creek and Battle Creek, spawning habitat WUA for both runs peaks at about 3,500 cfs. The highest density of redds for fall- and late fall-run Chinook Salmon occur in the middle ACID intake to Cow Creek reach.

The spawning habitat WUA values for steelhead peaks at the lowest river flow analyzed (3,250 cfs) in the reach upstream of the ACID intake. This habitat relationship held regardless of whether the flashboards were in or out. In the reach between the ACID intake and Cow Creek, spawning habitat WUA peaks at river flows around 6,000 cfs. In the lower reach, from Cow Creek to Battle Creek, spawning habitat WUA also peaks at river flows of about 6,500 cfs, but do not vary substantially in a flow range between about 4,000 and 8,000 cfs.

USFWS (2005b) conducted limiting life-stage analyses for winter-, fall-, and late-fall-run Chinook Salmon in the Sacramento River upstream of the Battle Creek confluence and found that in most cases, juvenile habitat is limiting. In some cases (fall- and late fall-run in between the ACID intake and Cow Creek), spawning habitat may be limiting at higher flows.

USFWS (2005a) developed spawning flow-habitat relationships for fall-run Chinook Salmon spawning habitat in the Sacramento River between Battle Creek and Deer Creek. Between Battle Creek and RBDD, spawning habitat WUA values for fall-run Chinook Salmon peaked at approximately 3,750 cfs, but showed little variation over flows from 3,250 cfs (the lowest flow evaluated) and 6,000 cfs, but declined substantially at higher flows. Between the Red Bluff Pumping Plant and Deer Creek, spawning habitat WUA values for fall-run Chinook salmon peaked at 5,500 cfs, with little variation at flows from 4,250 to 8,000 cfs (USFWS 2005a).

Rearing Habitat

In the Sacramento River between Red Bluff and Chico Landing, the mainstem channel is flanked by broad floodplains. Ongoing sediment deposition in these areas provides evidence of continued inundation of floodplains in this reach (DWR 1994). Between Chico Landing and Colusa, the Sacramento River is bounded by levees that provide flood protection for cities and agricultural areas. However, the levees in this portion of the Sacramento River are, for the most part, set back from the mainstem channel such that flooding can be significant within the river corridor (TNC 2007b).

Fry rearing habitat WUA for winter-run Chinook Salmon fry rearing habitat peaks at around 5,500 cfs in the reach upstream of the ACID intake when the dam flashboards are in. With the boards out, the peak is around 6,500 cfs. In the next reach downstream (ACID intake to Cow Creek), fry rearing habitat WUA for winter-run Chinook Salmon peaks at around 31,000 cfs (the highest flow evaluated). In the lower reach (Cow Creek to Battle Creek), fry rearing habitat WUA for winter-run Chinook Salmon also peaked at around 31,000 cfs, but there was little variation at flows.

The fry rearing habitat WUA values differ for fall-run and late fall-run Chinook Salmon, but the flow versus habitat relationship was similar for the two runs. Upstream of the ACID intake, fry rearing habitat WUA for fall- and late fall-run Chinook Salmon peaks at the lowest flow analyzed (3,250 cfs) with the dam flashboards in. With the flashboards out, fry rearing habitat WUA peaks at around 23,000 cfs for both species. Between the ACID intake and Cow Creek, fry rearing habitat WUA for fall- and late fall-run Chinook Salmon peaked at around 3,750 cfs for both runs, with little variation from 3,250 cfs to 6,000 cfs and only slightly lower WUA values at flows greater than 21,000 cfs. Between Cow Creek and Battle Creek, fry rearing habitat WUA for both runs peaks at 3,250 cfs (the lowest flow evaluated), declining as flows increase.

Juvenile rearing habitat WUA for winter-run Chinook Salmon juvenile rearing habitat peaks at around 8,000 cfs in the upstream reach above the ACID intake when the dam flashboards are in. With the boards out, the peak is around 9,000 cfs. However, there is little variation in juvenile winter-run Chinook Salmon rearing habitat WUA from around 5,500 to 11,000 cfs in this reach. In the next reach downstream between the ACID intake to Cow Creek, juvenile rearing habitat WUA for winter-run Chinook Salmon peaks at around 31,000 cfs (the highest flow evaluated). In the lower reach (Cow Creek to Battle Creek), juvenile rearing habitat WUA for winter-run Chinook Salmon peaks at around 3,500 cfs but shows only moderate (<50 percent) reductions in WUA over the entire range of flows evaluated.

The juvenile rearing habitat WUA values differ for fall-run and late fall-run Chinook Salmon, but the flow versus habitat relationship is similar for the two runs. Upstream of the ACID intake, juvenile rearing habitat WUA for fall- and late fall-run Chinook Salmon peaked in the 5,000- to 6,000-cfs range with the dam flashboards in or out; there were only moderate (<50 percent) reductions in juvenile rearing WUA over the entire range of flows evaluated. Between the ACID intake and Cow Creek, fry rearing WUA peaked at around 3,250 cfs (the lowest flow evaluated) for both runs, declining to a minimum at around 15,000 cfs and increasing to around 70 percent of the maximum at flows above 21,000 cfs. Between Cow Creek and Battle Creek, fry rearing WUA for both runs peaked at 3,250 cfs (the lowest flow evaluated), declining as flow increased.

Vogel (2011) suggested that the mainstem Sacramento River may not provide adequate rearing areas for fry-stage anadromous salmonids, as evidenced by rapid displacement of fry from upstream to downstream areas and into nonnatal tributaries during increased flow events. Underwater observations of salmon fry in the mainstem Sacramento River suggest that optimal habitats for rearing may be limited at higher flows (Vogel 2011). USFWS (2005) conducted limiting life-stage analyses for winter-, fall-, and late-fall-run Chinook Salmon in the

Sacramento River above Battle Creek and found that in most cases, juvenile habitat is limiting. An important limitation of this analysis is that it did not take into account fry and juvenile rearing habitat below Battle Creek or in the Delta.

The minimum required Sacramento River flow is 3,250 cfs. Flows during summer generally exceed this amount in order to meet temperature requirements for winter-run Chinook Salmon. The water temperature requirements established for winter-run Chinook Salmon result in water temperatures also suitable for year-round rearing of steelhead in the upper Sacramento River.

9.3.4.4.3 Fish Passage and Entrainment

Historically, anadromous salmonids had access to a minimum of approximately 493 miles of habitat in the Sacramento River (Yoshiyama et al. 1996). After completion of Shasta Dam in 1945, access to approximately 207 miles was blocked. Keswick Dam, just downstream of Shasta Dam, is now the upstream extent of available habitat for anadromous fish in the Sacramento River.

Until recently, three large-scale, upper Sacramento River diversions, including the ACID and GCID intakes and RBDD, were of particular concern as potential passage or entrainment problems for Chinook Salmon, steelhead, and other migratory fish species (NRC 2012, NMFS 2009a, McEwan and Jackson 1996). Recently, RBDD was eliminated, the GCID fish screens were installed, and fish passage at the ACID intake was improved (NRC 2012). At the ACID intake, new fish ladders and fish screens were installed around the diversion and were operated starting in the summer 2001 diversion period. However, adult Green Sturgeon that migrate upstream in April, May, and June are completely blocked by the ACID intake (NMFS 2009a), rendering approximately 3 miles of spawning habitat upstream of the diversion dam inaccessible. Adult Green Sturgeon that pass upstream of the intake before April are delayed for 6 months until the flashboards are pulled before returning downstream to the ocean. Newly emerged Green Sturgeon larvae that hatch upstream of the ACID intake would need to hold for 6 months upstream of the dam or pass over it and be subjected to higher velocities and turbulent flow below the intake (NMFS 2009a).

Numerous other diversions are located on the Sacramento River. Herren and Kawasaki (2001) documented up to 431 diversions from the Sacramento River between Shasta Dam and the City of Sacramento. Hanson (2001) studied juvenile Chinook Salmon entrainment at unscreened diversions at the Princeton Pumping Plant and documented the entrainment of approximately 0.05 percent of juvenile Chinook Salmon passing the diversion. Similar to the results of Hanson (2001), Vogel (2013) found that entrainment of juvenile salmon in 12 unscreened diversions was low relative to other fish species. The study did not discern measurable effects of factors such as size of the diversion, longitudinal location in the river, water temperatures, localized habitat conditions, intake position in the river channel, and depth of the intakes on salmonid entrainment. It appeared that juvenile salmon were entrained in a much lower proportion than the proportion of flow diverted (Vogel 2013), similar to results noted by Hanson (2001). Mussen et al. (2014) examined the risk to Green Sturgeon from unscreened water diversions and found that juvenile Green Sturgeon entrainment susceptibility (in a laboratory setting) was high relative to that estimated for Chinook Salmon, suggesting that unscreened diversions could be a contributing mortality source for threatened Southern DPS Green Sturgeon.

Reclamation is currently coordinating with USFWS to support improvements at other fish screens. In 2013, CVPIA funds were used to construct the Natomas Mutual Sankey Fish Screen on the Sacramento River that replaced two existing diversions on the Natomas Cross Canal. This project also resulted in the removal of an anadromous fish migration barrier (seasonal diversion dam) on the Natomas Cross Canal. The fish screening program also completed construction of four fish screens on the Sacramento River and one fish screen in the Delta.

Potential barriers to migration for adult Green Sturgeon into the upper reaches of the Sacramento River include structures such as the ACID intake, Sacramento River Deep Water Ship Channel locks, Fremont Weir, Sutter Bypass, and DCC gates on the Sacramento River (70 FR 17386). A set of locks at the end of the Sacramento River Deep Water Ship Channel at the connection with the Sacramento River "blocks the migration of all fish from the deep-water ship channel back to the Sacramento River" (DWR 2005).

9.3.4.4.4 Hatcheries

The Livingston Stone NFH, located at the foot of Shasta Dam, is a conservation hatchery that has been producing and releasing juvenile winter-run Chinook Salmon since 1998. There is growing concern about the potential genetic effects that may result from the use of a conventional hatchery program to supplement winter-run Chinook Salmon populations. To maintain a low risk of compromised genetic fitness, Lindley et al. (2007) recommend that no more than 5 percent of the naturally spawning population should be composed of hatchery fish. Since 2001, more than 5 percent of the winter-run Chinook Salmon run has been composed of hatchery-origin fish, and in 2005 the contribution of hatchery fish was more than 18 percent (Lindley et al. 2007).

The Livingston Stone NFH minimizes hatchery affects in the population by preferentially collecting wild adult winter-run Chinook Salmon for brood stock (USFWS 2011b). Up to 15 percent of the estimated run size for winter-run Chinook Salmon run may be collected for brood stock use (up to a maximum of 120 natural-origin winter-run Chinook Salmon per brood year). Although there is no adult production goal, Livingston Stone NFH releases up to 250,000 winter-run Chinook Salmon a year in late January or early February. Winter-run Chinook Salmon are released at the pre-smolt stage and are intended to rear in the freshwater environment prior to smoltification. The pre-smolts are released into the Sacramento River at Caldwell Park in Redding, about 10 miles downstream of the hatchery. All juvenile winter-run Chinook Salmon produced at Livingston Stone NFH are adipose fin-clipped and coded wire-tagged (CHSRG 2012).

The Delta Smelt propagation program at the Livingston Stone NFH is operated as a captive broodstock program. Delta Smelt propagation at Livingston Stone NFH functions as a backup refugial population. No Delta Smelt from the Livingston Stone NFH are currently released (USFWS 2011b).

9.3.4.4.5 Predation

On the mainstem Sacramento River, high rates of predation have been known to occur at the diversion facilities and areas where rock revetment has replaced natural river bank vegetation (NMFS 2009a). Chinook Salmon fry, juveniles, and smolts are more susceptible to predation at these locations because Sacramento Pikeminnow and Striped Bass congregate in areas that provide predator refuge (Williams 2006, Tucker et al. 2003).

9.3.4.5 Battle Creek

Battle Creek is a tributary that enters the Sacramento River about 20 miles southeast of Redding. The cold, spring-fed waters of Battle Creek historically supported large runs of Chinook Salmon and steelhead. Diversion dams constructed in the early 1900s for hydroelectric power production reduced instream flow and blocked anadromous salmonids from accessing habitat in large portions of the north and south forks of Battle Creek.

Coleman NFH, located on Battle Creek, was established in 1942 by Reclamation to partially mitigate habitat and fish losses from historical spawning areas caused by construction of two CVP features, Shasta and Keswick dams. The hatchery is funded by Reclamation and operated by USFWS. The steelhead program at the hatchery was initiated in 1947 to mitigate losses resulting from the CVP (USFWS 2012). The weir at the hatchery is a barrier to anadromous fish passage, as are various Pacific Gas & Electric Company (PG&E) dams (e.g., Wildcat) located on Battle Creek (Yoshiyama et al. 1996). Yoshiyama et al. (1996) reported that the Coleman South Fork Diversion Dam is the first impassible barrier on Battle Creek.

Beginning in 1995, planning was initiated to restore naturally spawning anadromous fish populations in Battle Creek, and construction began in 2010 on the Battle Creek Salmon and Steelhead Restoration Project (Reclamation 2014a). When complete, the Battle Creek restoration project will restore ecological processes along 42 miles of Battle Creek and 6 miles of tributaries while minimizing reductions to hydroelectric power generation, although five dams are decommissioned (Wildcat, Coleman, South, Lower Ripley, and Soap Creek feeder diversion dams). New fish screens and fish ladders that meet NMFS and CDFW criteria will be constructed at three diversion dams (North Battle Creek Feeder, Eagle Canyon, and Inskip Diversion Dams). Connectors are proposed that prevent the discharge of North Fork Battle Creek water to South Fork Battle Creek and the mixing of flow sources. Higher minimum flow requirements will increase instream flows, subsequently cooling water temperatures, increasing stream area, and providing reliable passage conditions for adult salmonids in downstream reaches. The project will result in 42 miles of newly accessible anadromous fish habitat and improved water quality for the Coleman NFH.

9.3.4.6 Lake Oroville and Thermalito Complex

Lake Oroville on the Feather River is formed by Oroville Dam, approximately 70 miles upstream from its confluence with the Sacramento River. Lake Oroville is fed by the north, middle, and south forks of the Feather River. A portion of the water released from Lake Oroville flows into the Thermalito Complex, as described in Chapter 5, Surface Water Resources and Water Supplies.

9.3.4.6.1 Fish in Lake Oroville

Lake Oroville thermally stratifies in spring, destratifies in fall, and remains destratified throughout winter. FERC (2007b) reports indicate that surface water temperatures of the epilimnion begin to warm in the early spring, reach maximum temperatures (approximately mid-80°F) during late July, and gradually decline to winter minimums. The transition zone (i.e., metalimnion) between the upper warmer and lower colder waters typically ranges from about 30 to 50 feet below the lake surface during midsummer. The deeper water of the hypolimnion can reach a temperature of about 44°F near the reservoir bottom during periods of stratification (FERC 2007b). Cold-water fish species include Coho Salmon, Rainbow Trout, Brown Trout, and Lake Trout. The Lake Oroville cold-water fishery is not self-sustaining, possibly because of insufficient spawning and rearing habitat in the reservoir and accessible tributaries; cold-water spawning is not known to occur in Lake Oroville. The Coho Salmon fishery is sustained by a “put-and-grow” hatchery stocking program (FERC 2007b). The Lake Oroville warm-water fishery is a regionally important self-sustaining recreational fishery and is the site of several annual bass fishing tournaments. Spotted Bass are the most abundant bass species in Lake Oroville, followed by Largemouth Bass, Redeye Bass, and Smallmouth Bass, respectively. Other important warm-water species include catfish, crappie, and sunfish. Common carp are also abundant in Lake Oroville.

9.3.4.6.2 Fish in Thermalito Forebay and Afterbay

Ambient meteorological conditions and the temperature of the water released from Lake Oroville generally affect water temperatures in the Thermalito Diversion Pool and Thermalito Forebay (FERC 2007b). Thermalito Forebay is an open, cold, shallow reservoir that remains cold throughout the year because it is supplied with water from Thermalito Diversion Pool, although pump-back operations from Thermalito Afterbay can increase water temperatures in the forebay. Thermalito Forebay provides habitat primarily for cold-water fish species, although the same warm-water fish species found in Lake Oroville are believed to exist in the forebay in low numbers (FERC 2007b). Additionally, CDFW manages a “put-and-take” trout fishery in Thermalito Forebay.

Thermalito Afterbay provides habitat for cold-water and warm-water fish species including Largemouth Bass, Smallmouth Bass, Rainbow Trout, Brown Trout, Bluegill, Redear Sunfish, Black Crappie, Channel Catfish, carp, and large schools of Wakasagi (FERC 2007b). A popular Largemouth Bass fishery currently exists, large trout are sometimes caught near the inlet, and an experimental steelhead fishery occurs in the Afterbay. Only limited salmonid stocking occurs at the afterbay, so these fish most likely passed through the Thermalito Pumping-Generating Plant from the forebay.

9.3.4.7 Feather River from Lake Oroville and the Thermalito Complex to the Sacramento River

The Feather River is a major tributary to the Sacramento River, providing approximately 25 percent of the flow in the Sacramento River (FERC 2007b). The lower Feather River extends downstream from the Fish Barrier Dam to the confluence with the Sacramento River near Verona. The Fish Barrier Dam is located downstream of the Thermalito Diversion Dam and immediately upstream of the Feather River Fish Hatchery (FERC 2007b).

9.3.4.7.1 Fish in the Feather River

The Feather River below Oroville supports a variety of anadromous and resident fish species. The distribution of anadromous fish in the Feather River is limited to approximately 67 miles of river downstream from the Fish Barrier Dam. At least 44 species of fish have been reported to historically or currently occur in the lower Feather River system, including numerous resident native and introduced species and several anadromous species (FERC 2007b).

The analysis is focused on the following species:

- Chinook Salmon (winter-, spring-, and fall/late fall-run)
- Steelhead
- Green Sturgeon
- White Sturgeon
- Sacramento Splittail
- Pacific Lamprey
- Striped Bass
- American Shad

Spring-run Chinook Salmon

Approximately two-thirds of the natural spring-run and fall-run Chinook Salmon spawning occur in the low-flow channel of the lower Feather River, downstream of the Fish Barrier Dam, and one-third of the spawning occurs in the high-flow channel downstream of the Thermalito Afterbay Outlet (FERC 2007b). NMFS (2009a) indicated that significant redd superimposition occurs in the lower Feather River because of oversaturation of the natural carrying capacity of the available spawning habitat (e.g., Sommer et al. 2001b) with an overproduction of hatchery spring-run Chinook Salmon and a lack of physical separation between spring-run and fall-run Chinook Salmon adults.

Adult spring-run Chinook Salmon typically enter fresh water in spring, hold over summer, and spawn in fall. Juveniles typically spend a year or more in fresh water before outmigrating. Adult spring-run Chinook Salmon begin their upstream migration from the ocean in late January and early February (DFG 1998b) and migrate from the Sacramento River into spawning tributaries primarily between mid-April and mid-June (Lindley et al. 2004). Adult Chinook

Salmon exhibiting the typical life history of the spring-run have been found holding at the Thermalito Afterbay Outlet and the Fish Barrier Dam as early as April (FERC 2007b). Spring-run Chinook Salmon spawning occurs during September and October, depending on water temperatures (NMFS 2012a). Spring-run Chinook Salmon fry emerge from the gravel from November to March (Moyle 2002). Most juvenile spring-run Chinook Salmon outmigrate from the lower Feather River within a few days of emergence, and 95 percent of the juvenile Chinook have typically outmigrated from the Oroville facilities project area by the end of May (FERC 2007b).

An independent population of spring-run Chinook Salmon historically occurred in the lower Feather River downstream of Oroville Dam, and a naturally spawning population of spring-run Chinook Salmon may persist in this reach (Lindley et al. 2004). The number of naturally spawning spring-run Chinook Salmon in the Feather River has been estimated only periodically since the 1960s, with estimates ranging from 2 fish in 1978 to 2,908 in 1964. However, the genetic integrity of this population is questionable because of the significant temporal and spatial overlap between spawning populations of spring-run Chinook Salmon and fall-run Chinook Salmon (Good et al. 2005).

Substantial numbers of spring-run Chinook Salmon, as identified by run timing, return to the Feather River Fish Hatchery. From 1986 to 2011, the median number of spring-run Chinook Salmon returning to the Feather River Fish Hatchery was 3,655, compared to a median of 7,869 spring-run Chinook Salmon returning to the entire Sacramento River Basin (NMFS 2012a). Abundance estimates of lower Feather River spring-run Chinook Salmon may be distorted by naturally occurring genetic introgression with fall-run Chinook Salmon, Feather River Fish Hatchery practices, and Federal and state escapement estimation methodology. Coded wire tags obtained from Feather River Fish Hatchery returns indicate substantial introgression has occurred between spring-run Chinook Salmon and fall-run Chinook Salmon populations within the lower Feather River (NMFS 2009a).

Fall-run Chinook Salmon

Fall-run Chinook Salmon generally begin upstream migration into the lower Feather River during summer months (FERC 2007b). Although timing of fall-run Chinook Salmon spawning may be influenced by water temperature conditions (FERC 2007b), spawning activity in the lower Feather River occurs from late August through December and generally peaks during mid- to late November (Myers et al. 1998). Concurrent spawning with spring-run Chinook Salmon, which generally occurs from September to October, has led to hybridization between the spring- and fall-run Chinook Salmon in the lower Feather River (NMFS 2012a).

In the lower Feather River, fall-run Chinook Salmon embryo incubation and alevin (yolk-sac fry) emergence generally occurs from mid-October through March, depending on water temperature conditions (FERC 2007b). Fall-run Chinook Salmon fry emergence generally occurs in the lower Feather River downstream of the Fish Barrier Dam from late December through March, and most juvenile fall-run Chinook Salmon outmigrate from the lower Feather River within a few days of emergence (FERC 2007b).

Steelhead

Steelhead immigrate into the Feather River from July to March (McEwan 2001). Currently, most of the natural steelhead spawning in the lower Feather River occurs in the low-flow channel downstream of the Fish Barrier Dam; however, limited spawning also occurs downstream of the Thermalito Afterbay Outlet (FERC 2007b). Results of a 13-week redd survey conducted between January 6 and April 3, 2003, indicated that redd construction generally occurs in the lower Feather River between late December and March, peaking in late January (FERC 2007b). The FERC (2007b) study suggests that nearly half (48 percent) of all redds were constructed in the uppermost mile of the low-flow channel downstream of the Fish Barrier Dam. Redd density in this 1-mile section of the low-flow channel was approximately 36 redds per mile, more than 10 times more than any other section of the lower Feather River (FERC 2007b).

A moderate percentage of the steelhead fry appear to outmigrate from the lower Feather River soon after emerging from the gravel. Juvenile steelhead that do not outmigrate may rear in the river for up to 1 year. Juvenile steelhead in the Feather River outmigrate from about February through September, with peak outmigration occurring from March through mid-April. In-river juvenile rearing is generally associated with secondary channels in the low-flow channel (e.g., Hatchery Ditch) (FERC 2007b).

Pacific Lamprey

The Pacific Lamprey inhabits accessible reaches of the lower Feather River (DWR 2003a). Information on Pacific Lamprey status in the lower Feather River is limited, but the loss of access to historical habitat and apparent population declines throughout California and the Sacramento and San Joaquin River basins indicate populations are greatly decreased compared with historical levels (Moyle et al. 2009). Little information is available on factors limiting Pacific Lamprey populations in the lower Feather River, but they are likely affected by many of the same factors as salmon and steelhead because of parallels in their life cycles.

Ocean-stage adults likely migrate into the lower Feather River in spring and early summer, where they hold for approximately 1 year before spawning (Hanni et al. 2006). Hannon and Deason (2008) have documented Pacific Lamprey spawning in the nearby American River from between early January and late May, with peak spawning typically occurring in early April. Pacific Lamprey ammocoetes rear in the lower Feather River for all or part of their 5-¬ to 7-year freshwater residence. Data from rotary screw trapping suggest that outmigration of Pacific Lamprey generally occurs from early winter through early summer (Hanni et al. 2006), although some outmigration likely occurs year-round as observed in the mainstem Sacramento River (Hanni et al. 2006) and in other river systems (Moyle 2002).

Sacramento Splittail

Sacramento Splittail enter the lower Feather River, primarily in wet years, with most individuals collected in the high-flow channel downstream of Thermalito Afterbay Outlet (DWR 2004a). On the lower Feather River, February through May was assumed to encompass the period of splittail spawning, egg incubation, and initial rearing (Sommer et al. 2008, DWR 2004a). Splittail use shallow flooded vegetation for spawning and are infrequently observed in the Feather River from the confluence with the Sacramento River up to Honcut Creek. The majority of spawning activity in the Feather River is thought to occur downstream of the Yuba River confluence (FERC 2007b). The primary factor that likely limits the lower Feather River splittail population is availability of spawning and rearing habitats as related to inundation of floodplains (Moyle et al. 2004, DWR 2004a).

Green Sturgeon

Historically, Green Sturgeon likely spawned in the Sacramento, Feather, and San Joaquin rivers (Adams et al. 2007). A substantial amount of habitat in the Feather River was lost with the construction of Oroville Dam. Although the presence of Green Sturgeon in the Sacramento River has been supported by direct angler observations and rotary screw trapping of eggs, larvae, and YOY Green Sturgeon, only intermittent observations of Green Sturgeon have been reported in the lower Feather River (Beamesderfer et al. 2007). The occasional capture of larval Green Sturgeon in outmigrant traps suggests that Green Sturgeon spawn in the lower Feather River (Moyle 2002). However, prior to 2011 only two records of adult Green Sturgeon in the lower Feather River were confirmed (NMFS 2005b). In 2011, videography monitoring conducted by the Anadromous Fish Restoration Program confirmed Green Sturgeon spawning activity in the lower Feather River and found evidence of spawning behavior in the Yuba River (AFRP 2011). Seesholtz et al. (2014) provided the first documentation of Green Sturgeon spawning in the Feather River.

White Sturgeon

White Sturgeon are known to use the lower Feather River primarily for spawning, embryo development, and early rearing. Limited quantitative information is available on the status of White Sturgeon in the lower Feather River, but the spawning population was most likely much larger prior to construction of Oroville Dam in 1961 (Israel et al. 2008). Seesholtz (2003) reported no evidence of sturgeon was found in the lower Feather River after an exhaustive search for their presence in 2003. However, 16 White Sturgeon were recorded from creel surveys and sightings during 2006, and more were captured by anglers in 2007 (Israel et al. 2008). Numerous factors likely limit the success of the White Sturgeon population in the lower Feather River, but loss of historical habitat, alteration of temperatures and flows caused by Oroville Dam and other impoundments in the watershed, and recreational fishing and poaching are expected to be among the most important factors.

Striped Bass

Striped Bass occur in the lower Feather River and have been reported to occur in the Thermalito Forebay (FERC 2007b). Striped Bass are a popular sport fish in the lower Feather River during periods when they migrate upstream to spawn.

American Shad

American Shad enter the Feather River annually in spring to spawn and are popular for sport fishing. American Shad are present in the lower Feather River from May through mid-December during the adult immigration, spawning, and outmigration periods of their life cycle (DWR 2003a).

9.3.4.7.2 Aquatic Habitat

Historically, spawning habitat suitable for anadromous salmonid species likely existed above the current location of Oroville Dam on the Feather River (Yoshiyama et al. 2001). Extensive mining, irrigation, and development of hydroelectric dams significantly reduced the amount of suitable habitat for these species (Yoshiyama et al. 2001). Schick et al. (2005) estimated approximately 71 miles of suitable habitat was historically available for spring-run Chinook Salmon in the lower Feather River.

Most Chinook Salmon and steelhead spawning is concentrated in the uppermost 3 miles of accessible habitat in the lower Feather River downstream of the Feather River Fish Hatchery (FERC 2007b). As a result, salmonid spawning is concentrated to unnaturally high levels in the low-flow channel of the lower Feather River directly downstream of Oroville Dam and the Fish Barrier Dam. A physical habitat simulation analysis conducted by the California Department of Water Resources (DWR) in 2002 indicated that Chinook spawning habitat suitability in the low-flow channel reached a maximum between 800 and 825 cfs, and in the high-flow channel, it reached a maximum at 1,200 cfs. The steelhead spawning habitat index in the low-flow channel had no distinct optimum over the range of flow between 150 and 1,000 cfs. In the high-flow channel, spawning habitat suitability was maximized at a flow just under 1,000 cfs (DWR 2004b).

The FERC (2007b) study reported that an estimated 97 percent of the sediment from the upstream watershed is trapped in Lake Oroville, such that only very fine sediment is discharged from Lake Oroville to the lower Feather River. As a result, gravel and large woody material from upstream reaches are limited along the lower Feather River. The FERC (2007b) study reported that the median gravel diameter (D50) of surface samples suggests that gravels in the low-flow channel generally are too large for successful redd construction by steelhead or salmon and that armoring is particularly evident in this reach; however, suitability of gravel sizes for spawning Chinook Salmon generally increased with distance downstream of Oroville Dam. The study suggested that size distributions of subsurface gravel samples were similar in the low- and high-flow channels. Analyses of fine sediment (less than 6 mm in diameter) suggested that fine sediment within gravels in the lower Feather River were suitable for incubating Chinook Salmon and steelhead embryos (FERC 2007b).

9.3.4.7.3 Fish Passage

The Oroville facilities, including Oroville Dam, Thermalito Diversion Dam, and the Fish Barrier Dam, currently block the upstream migration of anadromous fish to historically available spawning areas in the upstream tributaries of the Feather River. In a study of Green Sturgeon passage impediments, FERC identified three potential physical barriers to upstream migration by Green Sturgeon in the lower Feather River during representative low-flow conditions (approximately 2,074 cfs during November 2002) and high-flow conditions (approximately 9,998 cfs during July 2003) (FERC 2007b). The three potential physical barriers are Shanghai Bench, the Sunset Pumps, and Steep Riffle (located 2 miles upstream of the Thermalito Afterbay Outlet). However, the study also noted that determinations of potential passage barriers in the lower Feather River are speculative.

9.3.4.7.4 Hatcheries

The Feather River Fish Hatchery is part of the SWP Oroville Complex and is a mitigation hatchery for loss of habitat upstream of DWR’s Oroville Dam that is no longer accessible to anadromous fish species (NMFS 2009a). Three hatchery programs are conducted here, producing fall-run Chinook Salmon, spring-run Chinook Salmon, and steelhead. The Feather River Fish Hatchery supports the only spring-run Chinook Salmon hatchery program currently in the Central Valley (CHSRG 2012). Spring-run Chinook Salmon produced at the Feather River Fish Hatchery are included in the listed spring-run Chinook Salmon ESU (70 FR 37160). FERC is in consultation with NMFS on the effects of relicensing Oroville Dam (including the effects of Feather River Fish Hatchery).

Fall-run Chinook Salmon in the Feather River are trapped and spawned at the hatchery with a goal of producing 6 million fall-run Chinook Salmon smolts for release into Carquinez Straits between April and June. Up to 2 million additional fish may be reared as part of a separate ocean enhancement program. Feather River fall-run Chinook Salmon are currently marked at a 25 percent rate (constant fractional marking) with an adipose fin-clip and a coded wire-tag (CHSRG 2012).

Adult hatchery-produced spring-run Chinook are intended to spawn naturally or to be genetically integrated with the natural population through artificial propagation. There are no specific goals for the number of adult spring-run Chinook Salmon; however, the juvenile production goal is to release 2 million smolts during April or May. These fish are all released into the Feather River south of Yuba City at the Boyd’s Pump Boat Launch (44 miles downstream of the hatchery). Juvenile hatchery-produced spring-run Chinook Salmon are currently 100 percent marked with an adipose fin-clip and a coded wire-tag (CHSRG 2012).

The steelhead program at the Feather River Hatchery traps and artificially spawns both marked hatchery-origin and unmarked natural-origin steelhead. Only a few unmarked fish are trapped annually. Currently, only fish returning to the Feather River Basin are used for broodstock. There are no specific goals for the number of adult steelhead produced by this program; however, the juvenile production goal is to release 450,000 yearling steelhead annually during late January or February. All Feather River Hatchery steelhead are marked with an adipose fin-clip prior to release. These fish are all released into the Feather River south of Yuba City at the Boyd's Pump Boat Launch or at the confluence of the Feather and Sacramento rivers (Verona Marina) (CHSRG 2012).

Prior to 2004, separation of spring-run and fall-run Chinook Salmon returning to the Feather River Fish Hatchery was solely based on run timing, which resulted in considerable mixing of fall-run and spring-run Chinook Salmon stocks (DWR 2009, NMFS 2012a). In 2005, the Feather River Fish Hatchery implemented a methodology change for distinguishing spring-run Chinook Salmon from fall-run Chinook Salmon (CHSRG 2012). To maintain genetic integrity, fish entering the Feather River Fish Hatchery prior to July 1 receive an external tag, and only these externally tagged fish are used as spring-run Chinook Salmon broodstock (DWR 2009). Since 2005, the hatchery has attempted to mark 100 percent of spring-run Chinook Salmon produced at the hatchery with an adipose fin-clip, coded wire-tag (CHSRG 2012) and race and brood year specific otolith thermal marks (DWR 2009).

The Feather River Fish Hatchery employs best management practices and protocols to avoid the spread of diseases from the hatchery. The hatchery has been successful in adaptively managing disease concerns as they arise by the installing an ultraviolet treatment system, modifying the stocking of Lake Oroville, conducting periodic testing, and using prescribed therapeutic treatments (DWR 2004c).

9.3.4.7.5 Disease

Several endemic salmonid pathogens and diseases occur in the Feather River Basin, including *Ceratomyxa shasta* (salmonid ceratomyxosis), *Flavobacterium columnare* (columnaris), Infectious Hematopoietic Necrosis (IHN) virus, *Renibacterium salmoninarum* (bacterial kidney disease), and *Flavobacterium psychrophilum* (cold-water disease) (DWR 2004c). Each of these diseases has been shown to infect stocked and native salmonids in the Feather River; however, these diseases are not known to infect non-salmonids (FERC 2007b). Whirling disease has never been detected in the lower Feather River downstream of Oroville Dam, but has been found in upstream tributaries such as the north and south forks of the Feather River (DWR 2004c). Of the fish diseases in the Feather River Basin, IHN and salmonid ceratomyxosis are main contributors to fish mortality at the Feather River Fish Hatchery and are of highest concern for fisheries management in the region (DWR 2004c). The Feather River Fish Hatchery experienced severe IHN outbreaks in 2000 and 2001. A study by the University of California at Davis and USFWS indicated that although there were no clinical signs of disease, adult salmonids returning to either the Yuba or the Feather rivers demonstrated IHN infection rates of 28 percent and 18 percent, respectively (Brown et al. 2004).

Salmonid ceratomyxosis is endemic to the Feather River Basin; local salmonid stocks have co-evolved with this pathogen and exhibit some natural resistance. Salmonid ceratomyxosis causes mortality in all ages of anadromous and resident trout and salmon, although Rainbow Trout and steelhead are more susceptible to the disease than are Chinook and Coho Salmon (DWR 2004c). Mortality generally occurs when water temperatures exceed 50°F; however, fish can become infected at temperatures as low as 39°F (Bartholomew 2012).

9.3.4.7.6 Predation

The FERC (2007b) study suggests that the Fish Barrier Dam, which directs most anadromous salmonid spawning to occur in the low-flow channel, concentrates juvenile salmonids within this reach. Counts of known predators on juvenile anadromous salmonids in the low-flow channel are reported to be low; however, significant numbers of predators reportedly do exist in the high-flow channel downstream of Thermalito Afterbay Outlet (Seesholtz et al. 2004). Limited information is available to estimate the current rate of predation on juvenile salmonids in the lower Feather River.

9.3.4.8 Yuba River

Portions of the Yuba River watershed along the North Yuba River between New Bullards Bar Reservoir and Englebright Lake and along the Lower Yuba River between Englebright Lake and the Feather River could be affected by operation of the Lower Yuba River Water Accord (DWR et al. 2007), as described in Chapter 5, Surface Water Resources and Water Supplies.

Fish species found in the New Bullards Bar Reservoir include Rainbow Trout, Brown Trout, Kokanee Salmon, bass, Bluegill, crappie, and bullhead (DWR et al. 2007). A similar mix of species is found in Englebright Reservoir. Fall-run and spring-run Chinook Salmon and steelhead occur in the Yuba River downstream of Englebright Dam (YCWA 2009). Sacramento Splittail have been documented only in the lower Feather River and not in the Yuba River. Low numbers of Green Sturgeon and White Sturgeon occasionally range into the Yuba River (Beamesderfer et al. 2004). Other species found in the lower Yuba River include American Shad, Smallmouth Bass, and Striped Bass (DWR et al. 2007).

9.3.4.9 Bear River

The Bear River flows into the Feather River downstream of the confluence of the Feather and Yuba rivers. The Bear River includes Nevada Irrigation District’s Rollins and Combie reservoirs along the upper and middle reaches of the Bear River and South Sutter Water District’s Camp Far West Reservoir along the lower reach of the Bear River (FERC 2013, NID 2005).

Fall-run and spring-run Chinook Salmon and steelhead occur in the Bear River (YCWA 2009). Sacramento Splittail have been documented only in the lower Feather River and not in the Bear River. Low numbers of Green Sturgeon and White Sturgeon occasionally range into the Bear River (Beamesderfer et al. 2004). Rollins Reservoir is currently managed as a put-and-take fishery for rainbow and Brown Trout. Kokanee reproduce naturally in the lake. Gill net surveys from 1970 to 1983 documented numerous other species including bass, catfish, sunfish, Golden Shiner, Tui Chub, Pond Smelt, crappie, and Bluegill (DFG 1974-1983 in NID 2008). Native fishes found in Combie Reservoir may include Sacramento Pikeminnow, Sacramento Sucker, Hardhead, Tui Chub, Hitch, and Inland Silverside. Nonnative fishes likely include Bluegill, Green Sunfish, Largemouth Bass, Spotted Bass, Smallmouth Bass, common carp, Golden Shiner, Threadfin Shad, Black Crappie, Brown Bullhead, White Catfish, Channel Catfish, Western Mosquitofish, and stocked Rainbow Trout (NID 2009).

9.3.4.10 Folsom Lake and Lake Natoma

The American River watershed encompasses approximately 2,100 square miles (Reclamation et al. 2006). The three forks of the American River (north, middle, and south forks) converge upstream of Folsom Dam, with the combined flow moving through Lake Natoma and the lower American River for about 23 miles before entering the Sacramento River.

Water surface elevations vary annually as a result of seasonal inflow and water release and are generally the least variable during spring and most variable during summer (USACE et al. 2012). Thermal stratification of the reservoir generally begins during April and usually persists throughout summer until November, when cooler temperatures, winter rains, and high inflows create mixing and result in “turnover” (Reclamation 2005, USACE et al. 2012). During summer, a thermocline develops that separates the epilimnion (i.e., upper layer of warm water) and the hypolimnion (i.e., lower layer of cooler water). This thermal stratification and segregation of habitats allow for both cold-water and warm-water species to coexist in Folsom Lake (USACE et al. 2012). Warm-water fish species include native Hardhead, California Roach, Sacramento Pikeminnow, and Sacramento Sucker, as well as nonnative Largemouth Bass, Smallmouth Bass, Spotted Bass, sunfish, Black Crappie, and White Crappie (Reclamation 2007). Cold-water fish species include native Rainbow Trout and planted Chinook and Kokanee Salmon, as well as nonnative Brown Trout (Reclamation 2007).

Nimbus Dam creates Lake Natoma, which serves as a regulating afterbay to the Folsom power plant, maintaining more uniform flows in the lower American River. Lake Natoma is a shallow reservoir with an average depth of about 16 feet (Reclamation 2005). Surface water elevations in Lake Natoma may fluctuate between 4 and 7 feet daily (USACE et al. 2012). Lake Natoma has relatively low productivity as a fishery due to the effects of wide water temperature variability associated with the lake fluctuating elevation. Reclamation (2007) reports that fish species found in Lake Natoma are generally the same as those in Folsom Lake. Although CDFW annually stocks Lake Natoma with hatchery Rainbow Trout, conditions in Lake Natoma are more favorable for warm-water fish species (Reclamation 2007).

9.3.4.11 Lower American River between Lake Natoma and the Sacramento River

The lower American River extends approximately 23 miles from Nimbus Dam downstream to the confluence with the Sacramento River. Access to the upper reaches of the river by anadromous fish is blocked at Nimbus Dam.

9.3.4.11.1 Fish in the Lower American River

The lower American River system supports numerous resident native and introduced species as well as several anadromous species.

The analysis is focused on the following species:

- Fall-run Chinook Salmon
- Steelhead
- White Sturgeon
- Sacramento Splittail
- Pacific Lamprey
- Striped Bass
- American Shad

Fall-run Chinook Salmon

Historically, the American River supported fall-run and perhaps late fall-run Chinook Salmon (Williams 2001). Both naturally and hatchery produced Chinook Salmon spawn in the lower American River. Recent analysis by DFG and USFWS (2010) indicated that approximately 84 percent of the natural fall-run Chinook Salmon spawners in the American River are hatchery-origin fish. Kormos et al. (2012) reported that 79 percent of the fall-run Chinook Salmon entering the Nimbus Fish Hatchery in 2010 and 32 percent of the fish spawning in the American River were of hatchery origin.

Adult fall-run Chinook Salmon enter the lower American River from about mid-September through January, with peak migration from approximately mid-October through December (Williams 2001). Spawning occurs from about mid-October through early February, with peak spawning from mid-October through December. Chinook Salmon spawning occurs within an 18-mile stretch from Paradise Beach to Nimbus Dam; however, most spawning occurs in the uppermost 3 miles (DFG 2012a). Chinook Salmon egg and alevin incubation occurs in the lower American River from about mid-October through April. There is high variability from year to year; however, most incubation occurs from about mid-October through February. Chinook Salmon fry emergence occurs from January through mid-April, and juvenile rearing extends from January to about mid-July (Williams 2001). Most Chinook Salmon outmigrate from the lower American River as fry between December and July, peaking in February to March (Snider and Titus 2002, PSMFC 2014).

Steelhead

Natural spawning by steelhead in the American River occurs (Hannon and Deason 2008), but the population is supported primarily by the Nimbus Fish Hatchery. The total estimated steelhead return to the river (spawning naturally and in the hatchery) has ranged from 946 to 3,426 fish, averaging 2,184 fish per year from 2002 to 2010 (CHSRG 2012). Steelhead spawning surveys have shown approximately 300 steelhead spawning in the river each year (Hannon and Deason 2008). Lindley et al. (2007) classifies the listed (i.e., naturally spawning) population of American River steelhead at a high risk of extinction because it is reportedly mostly composed of steelhead originating from Nimbus Fish Hatchery. NMFS views the American River population as important to the survival and recovery of the species (NMFS 2009a).

Nielsen et al. (2005) found steelhead in the American River to be genetically different from other Central Valley stocks. Eel River steelhead were used to found the Nimbus Hatchery stock, and steelhead from the American River (collected from both the Nimbus Fish Hatchery and the American River) are genetically more similar to Eel River steelhead than other Central Valley Steelhead stocks. Based on studies by Hallock et al. (1961), Staley (1976), and Neilsen (2005), Lee and Chilton (2007) reported that American River winter-run steelhead are genetically and phenotypically different, and demonstrate a later upstream migration period than Central Valley Steelhead. Zimmerman et al. (2008) also noted that there remains a strong resident component (i.e., fish that do not migrate to the ocean) of the *O. mykiss* population that interacts with and produces anadromous individuals. Steelhead and Rainbow Trout are the same species and when juveniles of the species are found in fresh water, it is unclear if they will exhibit an anadromous (steelhead) or resident (Rainbow Trout) life history strategy. Thus, they are often collectively referred to as *O. mykiss* at this stage to indicate this uncertainty.

Adult steelhead enter the American River from November through April with a peak occurring from December through March (SWRI 2001). Steelhead have been trapped at Nimbus Fish Hatchery as early as the first week of October. Results of a spawning survey conducted from 2001 through 2007 indicate that steelhead spawning occurs in the lower American River from late December through early April, with the peak occurring in late February to early March (Hannon and Deason 2008). Spawning density is highest in the upper 7 miles of the river, but spawning occurs as far downstream as Paradise Beach. About 90 percent of spawning occurs upstream of the Watt Avenue Bridge (Hannon and Deason 2008).

Embryo incubation begins with the onset of spawning in late December and generally extends through May, although incubation can occur into June in some years (SWRI 2001). Steelhead embryo and alevin mortality associated with high flows in the American River has not been documented, but flows high enough to mobilize spawning gravels do occur during the spawning and embryo incubation periods (i.e., late December through early April) (NMFS 2009a).

Juvenile *O. mykiss* have been documented year-round throughout the lower American River, with rearing generally upstream of spawning areas. Juveniles reportedly can rear in the lower American River for a year or more before outmigrating as smolts from January through June (Snider and Titus 2000a, SWRI 2001). However, Snider and Titus (2002) reported only 1 yearling steelhead capture, and PSMFC (2014) reported capturing primarily YOY fry and parr. Peak outmigration occurs from March through May (McEwan and Jackson 1996, SWRI 2001, PSMFC 2014).

Rearing habitat for juvenile steelhead in the lower American River occurs throughout the upper reaches downstream to Paradise Beach. In summer, juveniles occur in most major riffle areas, with the highest concentrations near the higher density spawning areas (Reclamation 2008a). The number of juveniles in the American River decreases throughout summer (Reclamation 2008a). Warm water temperatures stress juvenile steelhead rearing in the American River, particularly during summer and early fall (LARTF 2002, Water Forum 2005c, NMFS 2014b). However, laboratory studies suggest that American River steelhead may be more tolerant of high temperatures than steelhead from regions farther north (Myrick and Cech 2004).

Pacific Lamprey

The Pacific Lamprey inhabits accessible reaches of the American River. Information on the status of Pacific Lamprey in the American River is limited, but the loss of historical habitat and apparent population declines throughout California indicate populations are greatly decreased compared to historical levels (Moyle et al. 2009).

Hannon and Deason (2008) documented Pacific Lamprey spawning in the American River between early January and late May, with peak spawning typically in early April. Pacific Lamprey ammocoetes rear in the American River for all or part of their 5¬- to 7-year freshwater residence. Data from rotary screw trapping in the nearby Feather River suggest that outmigration of Pacific Lamprey generally occurs from early winter through early summer (Hanni et al. 2006), although some outmigration likely occurs year-round, as observed at sites on the mainstem Sacramento River (Hanni et al. 2006) and in other river systems (Moyle 2002).

Because of the parallels in their life cycles, particularly spawning, lampreys may be affected by many of the same factors as salmon and steelhead. Little information is available on factors influencing Pacific Lamprey populations in the American River, but the dams likely play an important role. Moyle et al. (2009) suggested that in addition to blocking upstream migration, dams may disrupt upstream sediment inputs required to maintain habitat for ammocoetes and subject ammocoetes to rapid decreases in stream flow. Moyle et al. (2009) also indicated that ramping rates sufficient to protect salmonids may not be adequate to prevent the stranding of ammocoetes and metamorphosing individuals, which are vulnerable to desiccation and avian predation. Additionally, commercial harvest of lampreys on the American River (presumably for bait) may reduce spawning success in some years (Hannon and Deason 2008).

Sacramento Splittail

Splittail likely spawn in the lower reaches of the American River (Sommer et al. 1998, 2008; Moyle et al. 2004). During wet years, upstream migration is more directed and fish tend to swim farther upstream (Moyle 2002), thus more individuals are expected to use the American River in wet years. Although juvenile splittail are known to rear in upstream areas for a year or more (Baxter 1999), most move to the Delta after only a few weeks of rearing on floodplain habitat (Reclamation 2008a). Most juveniles move downstream into the Delta from April to August (Meng and Moyle 1995). The primary factor potentially limiting the American River population of Sacramento Splittail is availability of inundated floodplains for spawning and rearing habitats (Moyle et al. 2004).

White Sturgeon

Limited quantitative information is available on the distribution and status of White Sturgeon in the American River; however, small numbers of adults apparently use the American River, as evidenced by sturgeon report cards submitted to CDFW by anglers in recent years (e.g., DFG 2012b).

Striped Bass

Striped Bass are found in the American River throughout the year, with the greatest abundance in summer (SWRI 2001). Although the occurrence of spawning in the American River is uncertain, the river is believed to serve as a nursery area for YOY and subadult Striped Bass (SWRI 2001). Striped Bass are distributed from the confluence with the Sacramento River to Nimbus Dam (Moyle 2002), and they provide a locally important sportfishing resource.

American Shad

Adult American Shad ascend the lower American River to spawn during the late spring. During this period, they provide an important sport fishery. The shortage of adequate attraction flows in major tributaries such as the American River may be contributing to declines in the population (Moyle 2002).

9.3.4.11.2 Aquatic Habitat

Since 1955, Nimbus Dam has blocked upstream passage by anadromous fish and restricted available habitat in the lower American River to the approximately 23 river miles between the dam and the confluence with the Sacramento River. Additionally, Folsom Dam has blocked the downstream transport of sediment that contributes to the formation and maintenance of habitat for aquatic species.

In 2008, Reclamation, in coordination with USFWS and the Sacramento Water Forum, began implementation of salmonid habitat improvement in the lower American River. An estimated 5,000 cubic yards of gravel and cobble were placed just upstream of Nimbus Fish Hatchery in 2008, followed by an estimated 7,000 cubic yards adjacent to the Nimbus Fish Hatchery in fall 2009. In September 2010, approximately 11,688 cubic yards (approximately 16,200 tons) of gravel and cobble were placed at Sailor Bar to enhance spawning habitat for Chinook Salmon and steelhead in the lower American River (Merz et al. 2012). Additionally, the 2010 augmentation site contained a constructed cobble island

and “scallops” in the substrate designed to add habitat heterogeneity to the main channel and rearing habitat for juvenile Chinook Salmon and steelhead. Additionally, approximately 5,500 tons of cleaned cobble were placed downstream of the 2010 augmentation site. The specific purpose of this placement was to divert flow into an adjacent, perched side channel, thereby preventing the dewatering of salmonid redds in a historically important spawning and rearing area during low-flow conditions.

During higher flows, channel geomorphology in the lower American River is characterized by bar complexes and side channel areas, which may become limited at lower flows (NMFS 2009a). Spawning bed materials in the lower American River may begin to mobilize at flows of 30,000 cfs, with more substantial mobilization at flows of 50,000 cfs or greater (Reclamation 2008a). At 115,000 cfs (the highest flow modeled), particles up to 70 mm median diameter would be moved in the high-density spawning areas around Sailor Bar and Sunrise Avenue. Flood frequency analysis for the American River at Fair Oaks gage shows that, on average, flood control releases exceed 30,000 cfs about once every 4 years and exceed 50,000 cfs about once every 5 years (Reclamation 2008a).

In 2008, Reclamation began implementing floodplain and spawning habitat restoration projects in the American River to assist in meeting the requirements of the 1992 CVPIA, Section 3406 (b)(13). The side channel at Upper Sunrise was identified as a suitable site for steelhead spawning habitat restoration. In 2008, the CVPIA (b)(13) program cut and widened the side channel so that it inundated at a greater range of flows. The project reduced steelhead stranding, but also inadvertently reduced Chinook Salmon and steelhead spawning and rearing habitat (AFRP 2012). Consequently, the main channel was filled at the head-cut to create greater head pressure, thereby allowing flow once again through the side channel. Monitoring at the Upper Sunrise project revealed immediate response from Chinook Salmon and steelhead moving up into the side channel to spawn after completion of the project. Spawning and rearing habitat enhancement projects occurred each year from 2008 through 2014 in the reach from Nimbus Dam down to River Bend Park. These annual projects are planned to continue.

9.3.4.11.3 Fish Passage

Including the mainstem, north, middle, and south forks, more than 125 miles of riverine habitat historically were available for anadromous salmonids in the American River watershed (Yoshiyama et al. 1996). Access to the upper reaches of the river has been blocked by a series of impassable dams, including Old Folsom Dam, first constructed in the American River between 1895 and 1939.

Reclamation operates a fish diversion weir approximately 0.25 mile downstream of Nimbus Dam, which functions to divert adult steelhead and Chinook Salmon into Nimbus Fish Hatchery. The weir is annually installed during September prior to the arrival of fall-run Chinook Salmon and steelhead and is removed at the conclusion of fall-run Chinook Salmon immigration in early January (Reclamation and DFG 2011). Some steelhead may be trapped prior to weir removal, but they are returned to the river. A new fish passageway is being implemented in the Nimbus Dam stilling basin, commonly referred to as Nimbus Shoals. The passageway will replace the existing fish diversion weir with a new flume and fish ladder that will connect to the existing fish ladder near Nimbus Fish Hatchery.

9.3.4.11.4 Hatcheries

CDFW operates the Nimbus Salmon and Steelhead Hatchery and American River Trout Hatchery, located immediately downstream from Nimbus Dam. Facilities associated with Nimbus Fish Hatchery include a fish weir, fish ladder, gathering and handling tanks, hatchery-specific buildings, and rearing ponds. Nimbus Fish Hatchery was constructed primarily to mitigate the loss of spawning habitat for Chinook Salmon and Central Valley Steelhead that were blocked by the construction of Nimbus Dam (Reclamation and DFG 2011); it does not address lost habitat upstream from Folsom Dam (CHSRG 2012). The hatchery operations include the trapping, artificial spawning, rearing, and release of steelhead and fall-/late fall-run Chinook Salmon. Propagation programs for American River winter-run steelhead and Central Valley fall/ late fall-run Chinook Salmon are operated by CDFW under contract with Reclamation (Lee and Chilton 2007). The Nimbus Fish Hatchery Winter-run Steelhead Program is an isolated-harvest program (i.e., it does not include natural-origin steelhead in the broodstock), designed and implemented to artificially spawn the adipose fin-clipped adult steelhead that seasonally enter the trapping facilities (CHSRG 2012). These fin-clipped fish are not part of the Central Valley Steelhead DPS. The Nimbus Fish Hatchery Winter-run Steelhead Program propagates fish for recreational fishing opportunities and harvest (CHSRG 2012).

Steelhead have been trapped at Nimbus Fish Hatchery as early as the first week of October; however, since 2000, the ladder has been opened in early November. Trapping of steelhead has continued to occur as late as the second week of March. Presently, winter-run steelhead are trapped at Nimbus Fish Hatchery, and artificially spawned adults are marked with an adipose fin clip (CHSRG 2012). Unmarked steelhead adults are not retained at Nimbus Fish Hatchery for use in the annual broodstock and are released back to the river (CHSRG 2012). In addition, marked or unmarked *O. mykiss* that are less than 16 inches long may be resident hatchery-origin trout and are returned to the river (CHSRG 2012).

On average, the program has raised and released approximately 422,000 yearling steelhead since brood year 1999 (CHSRG 2012). Since 1998, all steelhead/Rainbow Trout produced in Nimbus Fish Hatchery have been marked with an adipose fin-clip to aid in subsequently identifying hatchery-origin fish.

Juvenile steelhead yearlings are not held past March 30 because of increasing hatchery water temperatures and to encourage outmigration during spring. If releases occur during periods of low flows in the Sacramento River and possibly the American River, some released fish migrate back to Nimbus Fish Hatchery and may take up residency rather than migrating downstream (Lee and Chilton 2007). Additionally, juvenile fish are released in February and early March to coincide with State Water Resources Control Board (SWRCB) D-1641 closures of the DCC gates from February 1 through May 20 to reduce straying into the Delta. Reclamation determines the exact timing and duration of the gate closures after discussion with USFWS, CDFW, and NMFS.

Reclamation is implementing a genetic screening study of Nimbus Fish Hatchery steelhead. Reclamation, in contract with NMFS, is conducting a parental-based tagging study of American River steelhead and continuing a study to determine a more genetically appropriate stock.

CDFW releases all hatchery-produced steelhead juveniles into the American River at boat ramps on the American River or at the confluence of the Sacramento and American rivers and releases all unclipped steelhead adults returning to Nimbus Fish Hatchery into the lower American River via the river return tube that is just downstream of the fish ladder. In accordance with California law, the current protocol of Nimbus Fish Hatchery is to destroy all surplus eggs to prevent inter-basin transfer of eggs or juveniles to other hatcheries or waters.

The goal of the Nimbus Fish Hatchery Integrated Fall/Late Fall-run Chinook Salmon Program is to release 4 million smolts. Each fall, Nimbus Hatchery staff collect approximately 10,000 adult fall-run Chinook Salmon, with an annual goal of harvesting 8,000,000 eggs and releasing the 4,000,000 smolts. All adult fall-run Chinook Salmon collected at the hatchery are euthanized, and no trapped salmon are returned to the American River (Reclamation 2008a).

9.3.4.11.5 Disease

The occurrence of a bacterial-caused inflammation of the anal vent (commonly referred to as “rosy anus”) of steelhead in the lower American River has been reported by CDFW to be associated with relatively warm water temperatures (Water Forum 2005b). Anal vent inflammation of steelhead in the lower American River was observed in 2004 during periods when water temperatures were measured between 65°F and 68°F (Water Forum 2005a, 2005b). The Water Forum (2005b) suggested that, in addition to possible diminished immune system responses and incidences of diseases associated with elevated water temperatures, disease transmission may be exacerbated by crowding under conditions when water flows are reduced.

9.3.4.11.6 Predation

Reduced cold-water storage in Folsom Lake and using Folsom Lake to meet Delta water quality objectives and demands influence habitat conditions in the lower American River for warm-water predator species that feed on juvenile salmonids and potentially alter predation pressure (Water Forum 2005b). Additionally, isolation of redds in side channels resulting from fluctuations in Folsom Lake releases may increase predation of emergent fry (Water Forum 2005b).

9.3.4.12 Delta

Ecologically, the Delta consists of three major landscapes and geographic regions: (1) the north Delta freshwater flood basins composed primarily of freshwater inflow from the Sacramento River system; (2) the south Delta distributary channels composed of predominantly San Joaquin River system inflow; and (3) the central Delta tidal islands landscape wherein the Sacramento, San Joaquin, and east side tributary flows converge and tidal influences from San Francisco Bay are greater.

9.3.4.12.1 Fish in the Delta

The Delta provides unique and, in some places, highly productive habitats for a variety of fish species, including euryhaline and oligohaline resident species and anadromous species. For anadromous species, the Delta is used by adult fish during upstream migration and by rearing juvenile fish that are feeding and growing as they migrate downstream to the ocean. Conditions in the Delta influence the abundance and productivity of all fish populations that use the system. Fish communities currently in the Delta include a mix of native species, some with low abundance, and a variety of introduced fish, some with high abundance (Matern et al. 2002, Feyrer and Healey 2003, Nobriga et al. 2005, Brown and May 2006, Moyle and Bennett 2008, Grimaldo et al. 2012).

The analysis is focused on the following species:

- Chinook Salmon (winter-, spring-, and fall-/late fall-run)
- Steelhead
- Green Sturgeon
- White Sturgeon
- Sacramento Splittail
- Pacific Lamprey
- Striped Bass
- American Shad
- Delta Smelt
- Longfin Smelt
- Sacramento Splittail

The Interagency Ecological Program (IEP) has been monitoring fish populations in the San Francisco Estuary for decades. Survey methods have included beach seining, midwater trawls, Kodiak trawls, otter trawls, and other methods (Honey et al. 2004) to sample the pelagic fish assemblage throughout the estuary. Three of the most prominent resident pelagic fishes captured in the surveys (Delta Smelt, Longfin Smelt, and Striped Bass) have shown substantial long-term population declines (Kimmerer et al. 2000, Bennett 2005, Rosenfield and Baxter 2007). Reductions in pelagic fish abundance since 2002 have been recognized as a serious water and fish management issue and have become known as the Pelagic Organism Decline (POD) (Sommer et al. 2007a).

In response to the POD, the IEP formed a study team in 2005 to evaluate the potential causes of the decline. Since completion of the first set of studies in late 2005, alternative models have been developed based on the available data and at professional judgment of the POD-Modeling Team regarding the extent to which individual drivers are likely to affect each species-life stage. The nine drivers identified (Baxter et al. 2010) were: (1) mismatch of larvae and food; (2) reduced habitat space; (3) adverse water movement/transport; (4) entrainment; (5) toxic effects on fish; (6) toxic effects on fish food items; (7) harmful Microcystis aeruginosa blooms; (8) *Potamocorbula amurensis* effects on food availability; and (9) disease and parasites.

An overall negative trend in habitat quality has occurred for Delta Smelt and Striped Bass (and potentially other fish species) as measured by water quality attributes and midwater trawl catch data since 1967, with Delta Smelt and Striped Bass experiencing the most apparent declines in abundance, distribution, and a related index of environmental quality (Feyrer et al. 2007, 2010). More specifically, the position of X2 and water clarity may be important factors influencing the quality of habitat for these species (McNally et al. 2010). Other factors, such as the introduction of nonnative clam species, also contribute to reducing habitat quality. Pelagic habitat suitability in the San Francisco Estuary has been characterized by changes in X2 (Feyrer et al. 2007, 2010). The abundance of several taxa increases in years when flows into the estuary are high and X2 is pushed seaward (Jassby et al. 1995; Kimmerer 2002a, b), implying that the quantity or suitability of estuarine habitat increases when outflows are high. Recent analyses by Kimmerer et al. (2009) indicated that neither changes in area or volume of low salinity water (habitat) account for this relationship, except for striped bass and American shad. This suggests that X2 is indexing other environmental variables or processes rather than simple extent of habitat (Baxter et al. 2010).

Winter-run Chinook Salmon

Winter-run Chinook Salmon use the Delta for upstream migration as adults and for downstream migration and rearing as juveniles (del Rosario et al. 2013). Adults migrate through the Delta during winter and into late spring (May/June) enroute to their spawning grounds in the mainstem Sacramento River downstream of Keswick Dam (USFWS 2001b, 2003b). Adults are believed to primarily use the mainstem Sacramento River for passage through the Delta (NMFS 2009a). After entry into the Delta, juvenile winter-run Chinook Salmon remain and rear in the Delta until they are 5 to 10 months of age (based on scale analysis) (Fisher 1994, Myers et al. 1998). Although the duration of residence in the Delta is not precisely known, del Rosario et al. (2013) suggested that it can be up to several months. Winter-run Chinook Salmon juveniles have been documented in the north Delta (e.g., Sacramento River, Steamboat Slough, Sutter Slough, Miner Slough, Yolo Bypass, and Cache Slough complex); the central Delta (e.g., Georgiana Slough, DCC, Snodgrass Slough, and Mokelumne River complex below Dead Horse Island); south Delta channels, including Old and Middle rivers, and the joining waterways between Old and Middle rivers (e.g., Victoria Canal, Woodward Canal, and Connection Slough); and the western central Delta, including the mainstem channels of the Sacramento and San Joaquin rivers and Threemile Slough (NMFS 2009a).

Sampling at Chipps Island in the western Delta suggests that winter-run Chinook Salmon exit the Delta as early as December and as late as May, with a peak in March (Brandes and McLain 2001, del Rosario et al. 2013). The peak timing of the outmigration of juvenile winter-run Chinook Salmon through the Delta is corroborated by recoveries of winter-run-sized juvenile Chinook Salmon from the SWP Skinner Delta Fish Protection Facility and the CVP Tracy Fish Collection Facility in the south Delta (NMFS 2009a).

Spring-run Chinook Salmon

The Delta is an important migratory route for all remaining populations of spring-run Chinook Salmon. Like all salmonids migrating up through the Delta, adult spring-run Chinook Salmon must navigate the many channels and avoid direct sources of mortality (e.g., fishing and predation), but also must minimize exposure to sources of nonlethal stress (e.g., high temperatures) that can contribute to prespawn mortality in adult salmonids (Budy et al. 2002, Naughton et al. 2005, Cooke et al. 2006, NMFS 2009a). Habitat degradation in the Delta caused by factors such as channelization and changes in water quality can present challenges for outmigrating juveniles. Additionally, outmigrating juveniles are subjected to predation and entrainment in the project export facilities and smaller diversions (NMFS 2009a). Further detail is provided later in this section.

Spring-run Chinook Salmon returning to spawn in the Sacramento River system enter the San Francisco Estuary from the ocean in January to late February and move through the Delta prior to entering the Sacramento River. Several populations of spring-run Chinook Salmon occur in the Sacramento River Basin, but historical populations that occurred in the San Joaquin River and tributaries have been extirpated. The Sacramento River channel is the main spring-run Chinook Salmon migration route through the Delta. However, adult spring-run Chinook Salmon may stray into the San Joaquin River side of the Delta in response to water from the Sacramento River Basin flowing into the interconnecting waterways that join the San Joaquin River channel through the DCC, Georgiana Slough, and Threemile Slough. Closure of the DCC radial gates is intended to minimize straying, but some southward net flow still occurs naturally in Georgiana and Threemile sloughs.

Juvenile spring-run Chinook Salmon show two distinct outmigration patterns in the Central Valley: outmigrating to the Delta and ocean during their first year of life as YOY, or holding over in their natal streams and outmigrating the following fall/winter as yearlings. Peak movement of juvenile spring-run Chinook Salmon in the Sacramento River at Knights Landing generally occurs in December, and again in March. However, juveniles also have been observed migrating between November and the end of May (Snider and Titus 1998, 2000b, c, d; Vincik et al. 2006; Roberts 2007).

YOY spring-run Chinook Salmon presence in the Delta peaks during April and May, as suggested by the recoveries of Chinook Salmon in the CVP and SWP salvage operations and the Chipps Island trawls of a size consistent with the predicted size of spring-run fish at that time of year. However, it is difficult to distinguish the YOY spring-run Chinook Salmon outmigration from that of the fall-run due to the similarity in their spawning and emergence times and size. Together, these two runs generate an extended pulse of Chinook Salmon smolts outmigrating through the Delta throughout spring, frequently lasting into June. Spring-run Chinook Salmon juveniles also overlap spatially with juvenile winter-run Chinook Salmon in the Delta (NMFS 2009a). Typically, juvenile spring-run Chinook Salmon are not found in the channels of the eastern side of the Delta or the mainstem of the San Joaquin River upstream of Columbia and Turner Cuts.

Fall-/Late fall-run Chinook Salmon

Central Valley fall- and late fall-run Chinook Salmon pass through the Delta as adults migrating upstream and juveniles outmigrating downstream. Adult fall- and late fall-run Chinook Salmon migrating through the Delta must navigate the many channels and avoid direct sources of mortality and minimize exposure to sources of nonlethal stress. Additionally, outmigrating juveniles are subject to predation and entrainment in the project export facilities and smaller diversions.

Adult fall-run Chinook Salmon migrate through the Delta and into Central Valley rivers from June through December. Adult late fall-run Chinook Salmon migrate through the Delta and into the Sacramento River from October through April. Adult Central Valley fall- and late fall-run Chinook Salmon migrating into the Sacramento River and its tributaries primarily use the western and northern portions of the Delta, whereas adults entering the San Joaquin River system to spawn use the western, central, and southern Delta as a migration pathway.

Most fall-run Chinook Salmon fry rear in fresh water from December through June, with outmigration as smolts primarily from January through June. In general, fall-run Chinook Salmon fry abundance in the Delta increases following high winter flows. Smolts that arrive in the estuary after rearing upstream migrate quickly through the Delta and Suisun and San Pablo bays. A small number of juvenile fall-run Chinook Salmon spend over a year in fresh water and outmigrate as yearling smolts the following November through April. Late fall-run fry rear in fresh water from April through the following April and outmigrate as smolts from October through February (Snider and Titus 2000b). Juvenile Chinook Salmon were found to spend about 40 days migrating through the Delta to the mouth of San Francisco Bay (MacFarlane and Norton 2002).

Results of mark-recapture studies conducted using juvenile Chinook Salmon released into both the Sacramento and San Joaquin rivers have shown high mortality during passage downstream through the rivers and Delta (Brandes and McLain 2001, Newman and Rice 2002, Buchanan et al. 2013). Juvenile salmon migrating from the San Joaquin River generally experience greater mortality than fish outmigrating from the Sacramento River. In years when spring flows are reduced and water temperatures are increased, mortality is typically higher in both rivers. Closing the DCC gates and installation of the Head of Old River Barrier to reduce the movement of juvenile salmon into the south Delta from the Sacramento and San Joaquin rivers, respectively, may contribute to improved survival of outmigrating juvenile Chinook Salmon from these watersheds (see Section 9.3.4.12.6).

Although not directly comparable to these previous coded-wire tag studies in the San Joaquin River, Buchanan et al. (2013, 2015) found that survival of acoustically tagged hatchery-origin (Feather River) juvenile Chinook Salmon was either not statistically different between routes (2009) or was higher through the south Delta via the Old River route than via the San Joaquin River (2010). Additionally, most fish in the Old River that survived to the end of the Delta had been salvaged from the federal water export facility on the Old River and trucked around the remainder of the Delta (Buchanan et al. 2013, SJRGA 2013). Buchanan et al. 2013 indicated that the differences in their results compared to past CWT studies may reflect that an alternative non-physical barrier was being used during their investigation to examine its ability to keep fish out of the Old River instead of the HORB which is a physical barrier that reduces not only the number of fish, but also the majority of flows, from entering the Old River. Nonphysical barriers may deprive smolts routed to the San Joaquin River of the increased flows needed for improved survival and created habitat for increased predation at the site (Buchanan et al. 2013).

Juvenile fall- and late fall-run Chinook Salmon migrating through the Delta toward the Pacific Ocean use the Delta, Suisun Marsh, and the Yolo Bypass for rearing to varying degrees, depending on their life stage (fry versus juvenile), size, river flows, and time of year. Movement of juvenile Chinook Salmon in the estuarine environment is driven by the interaction between tidally influenced saltwater intrusion through San Francisco Bay and freshwater outflow from the Sacramento and San Joaquin rivers (Healey 1991).

In the Delta, tidal and floodplain habitat areas provide important rearing habitat for foraging juvenile salmonids, including fall-run Chinook Salmon. Studies have shown that juvenile salmon may spend 2 to 3 months rearing in these habitat areas, and losses resulting from land reclamation and levee construction are considered to be major stressors (Williams 2010). The channeled, leveed, and riprapped river reaches and sloughs common in the Delta typically have low habitat diversity and complexity, have low abundance of food organisms, and offer little protection from predation by fish and birds.

Steelhead

Upstream migration of steelhead begins with estuarine entry from the ocean as early as July and continues through February or March in most years (McEwan and Jackson 1996, NMFS 2009a). Populations of steelhead occur primarily within the watersheds of the Sacramento River Basin, although not exclusively. Steelhead can spawn more than once, with postspawn adults (typically females) potentially moving back downstream through the Delta after completion of spawning in their natal streams.

Adult steelhead can be present in portions of the Delta with suitable conditions during any month of the year. Upstream migrating adult steelhead enter the Sacramento and San Joaquin River basins through their respective mainstem river channels. Steelhead entering the Mokelumne River system (including Dry Creek and the Cosumnes River) and the Calaveras River system to spawn are likely to move up the mainstem San Joaquin River channel before branching off into the channels of their natal rivers, although some may detour through the South Delta waterways and enter the San Joaquin River through the Head of Old River.

Steelhead entering the San Joaquin River Basin appear to have a later spawning run, with adults entering the system starting in late October through December, indicating that migration up through the Delta may begin a few weeks earlier. During fall, warm water temperatures in the south Delta waterways and water quality impairment because of low dissolved oxygen at Stockton have been suggested as potential barriers to upstream migration (NMFS 2009a). Reduced water temperatures, as well as rainfall runoff and flood control release flows, provide the stimulus to adult steelhead holding in the Delta to move upriver toward their spawning reaches in the San Joaquin River tributaries. Adult steelhead may continue entering the San Joaquin River Basin through winter.

Juvenile steelhead can be found in all waterways of the Delta, but particularly in the main channels leading from their natal river systems (NMFS 2009a). Juvenile steelhead are recovered in trawls from October through July at Chipps Island and at Mossdale. Chipps Island catch data indicate there is a difference in the outmigration timing between wild and hatchery-reared steelhead smolts from the Sacramento and eastside tributaries. Hatchery fish are typically recovered at Chipps Island from January through March, with a peak in February and March corresponding to the schedule of hatchery releases of steelhead smolts from the Central Valley hatcheries (Nobriga and Cadrett 2001, Reclamation 2008a). The timing of wild (unmarked) steelhead outmigration is more spread out, and based on salvage records at the CVP and SWP fish collection facilities, outmigration occurs over approximately 6 months with the highest levels of recovery in February through June (Aasen 2011, 2012). Steelhead are salvaged annually at the project export facilities (e.g., 4,631 fish were salvaged in 2010, and 1,648 in 2011) (Aasen 2011, 2012).

Outmigrating steelhead smolts enter the Delta primarily from the Sacramento or San Joaquin River. Mokelumne River steelhead smolts can either follow the north or south branches of the Mokelumne River through the central Delta before entering the San Joaquin River, although some fish may enter farther upstream if they diverge from the south branch of the Mokelumne River into Little Potato Slough. Calaveras River steelhead smolts enter the San Joaquin River downstream of the Port of Stockton. Although steelhead have been routinely documented by CDFW in trawls at Mossdale since 1988 (SJRGA 2011), it is unknown whether successful outmigration occurs outside the seasonal installation of the barrier at the Head of Old River (between April 15 and May 15 in most years). Prior to the installation of the Head of Old River barrier, steelhead smolts exiting the San Joaquin River Basin could follow one of two routes to the ocean, either staying in the mainstem San Joaquin River through the central Delta, or entering the Head of Old River and migrating through the south Delta and its associated network of channels and waterways.

Green Sturgeon

Green Sturgeon reach maturity around 14 to 16 years of age and can live to be 70 years old, returning to their natal rivers every 3 to 5 years for spawning (Van Eenennaam et al. 2005). Adult Green Sturgeon move through the Delta from February through April, arriving at holding and spawning locations the upper Sacramento River between April and June (Heublein 2006, Kelly et al. 2007). Following their initial spawning run upriver, adults may hold for a few weeks to months in the upper river before moving back downstream in fall (Vogel 2008, Heublein et al. 2009), or they may migrate immediately back downstream through the Delta. Radio-tagged adult Green Sturgeon have been tracked moving downstream past Knights Landing during summer and fall, typically in association with pulses of flow in the river (Heublein et al. 2009), similar to behavior exhibited by adult Green Sturgeon on the Rogue River and Klamath River systems (Erickson et al. 2002, Benson et al. 2007).

Similar to other estuaries along the west coast of North America, adult and sub-adult Green Sturgeon frequently congregate in the San Francisco Estuary during summer and fall (Lindley et al. 2008). Specifically, adults and subadults may reside for extended periods in the central Delta as well as in Suisun and San Pablo bays, presumably for feeding, because bays and estuaries are preferred feeding habitat rich in benthic invertebrates (e.g., amphipods, bivalves, and insect larvae). In part because of their bottom-oriented feeding habits, sturgeon are at risk of harmful accumulations of toxic pollutants in their tissues, especially pesticides such as pyrethroids and heavy metals such as selenium and mercury (Israel and Klimley 2008, Stewart et al. 2004).

Juvenile Green Sturgeon and White Sturgeon are periodically (although rarely) collected from the lower San Joaquin River at south Delta water diversion facilities and other sites (NMFS 2009a; Aasen 2011, 2012). Green Sturgeon are salvaged from the south Delta Project diversion facilities and are generally juveniles greater than 10 months but less than 3 years old (Reclamation 2008a). NMFS (2005b) suggested that the high percentage of San Joaquin River flows contributing to the Tracy Fish Collection Facility could mean that some entrained Green Sturgeon originated in the San Joaquin River Basin. Jackson (2013) reported spawning by White Sturgeon in the San Joaquin River, and anglers have reported catching a few Green Sturgeon in recent years in the San Joaquin River (DFG 2012b).

After hatching, larvae and juveniles migrate downstream toward the Delta. Juveniles are believed to use the Delta for rearing for the first 1 to 3 years of their lives before moving out to the ocean and are likely to be found in the main channels of the Delta and the larger interconnecting sloughs and waterways, especially within the central Delta and Suisun Bay/Marsh. Project operations at the DCC have the potential to reroute Green Sturgeon as they outmigrate through the lower Sacramento River to the Delta (Israel and Klimley 2008, Vogel 2011).

When the DCC is open, there is no passage delay for adults, but juveniles could be diverted from the Sacramento River into the interior Delta. This has been shown to reduce the survival of juvenile Chinook Salmon (Brandes and McLain 2001, Newman and Brandes 2010, Perry et al. 2012), but it is unknown whether it has similar effects on Green Sturgeon.

White Sturgeon

White Sturgeon are similar to Green Sturgeon in terms of their biology and life history. Like Green Sturgeon and other sturgeon species, White Sturgeon are late-maturing and infrequent spawners, which makes them vulnerable to overexploitation and other sources of adult mortality. White Sturgeon are believed to be most abundant within the San Francisco Bay-Delta region (Moyle 2002). Both nonspawning adults and juveniles can be found throughout the Delta year-round (Radtke 1966, Kohlhorst et al. 1991, Moyle 2002, DWR et al. 2013). When not undergoing spawning or ocean migrations, adults and subadults are usually most abundant in brackish portions of the Bay-Delta (Kohlhorst et al. 1991). The population status of White Sturgeon in the Delta is unclear, but it is not presently listed. Overall, information on trends in adults and juveniles suggests that numbers are declining (Moyle 2002, NMFS 2009a).

The Delta population of White Sturgeon spawns mainly in the Sacramento and Feather rivers, with occasional spawning in the San Joaquin River (Moyle 2002, Jackson 2013). Spawning-stage adults generally move into the lower reaches of rivers during winter prior to spawning and migrate upstream in response to higher flows to spawn from February to early June (McCabe and Tracy 1994, Schaffter 1997).

After absorbing yolk sacs and initiating feeding, YOY White Sturgeon make an active downstream migration that disperses them widely to rearing habitat throughout the lower rivers and the Delta (McCabe and Tracy 1994). White Sturgeon larvae have been observed to be flushed farther downstream in the Delta and Suisun Bay in high outflow years, but are restricted to more interior locations in low outflow years (Stevens and Miller 1970).

Salinity tolerance increases with increasing age and size (McEnroe and Cech 1985), allowing White Sturgeon to access a broader range of habitat in the San Francisco Estuary (Israel et al. 2008). During dry years, White Sturgeon have been observed following brackish waters farther upstream, while the opposite occurs in wet years (Kohlhorst et al. 1991). Adult White Sturgeon tend to concentrate in deeper areas and tidal channels with soft bottoms, especially during low tides, and typically move into intertidal or shallow subtidal areas to feed during high tides (Moyle 2002). These shallow water habitats provide opportunities for feeding on benthic organisms, such as opossum shrimp, amphipods, and even invasive overbite clams, and small fishes (Israel et al. 2008, Kogut 2008). White Sturgeon also have been found in tidal habitats of medium-sized tributary streams to the San Francisco Estuary, such as Coyote Creek and Guadalupe River in the south bay and Napa and Petaluma rivers and Sonoma Creek in the north bay (Leidy 2007).

Numerous factors likely affect the White Sturgeon population in the Delta, similar to those for Green Sturgeon. Survival during early life history stages may be adversely affected by insufficient flows, lack of rearing habitat, predation, warm water temperatures, decreased dissolved oxygen, chemical toxicants in the water, and entrainment at diversions (Cech et al. 1984, Israel et al. 2008). Historical habitats, including shallow intertidal feeding habitats, have been lost in the Delta because of channelization. Over-exploitation by recreational fishing and poaching also likely has been an important factor adversely affecting numbers of adult sturgeon (Moyle 2002), although new regulations were implemented in 2007 by CDFW to reduce harvest. Like Green Sturgeon, there are substantial passage problems for White Sturgeon such as the Fremont Weir (Sommer et al. 2014).

Delta Smelt

Delta Smelt are endemic to the Delta (Moyle et al. 1992, Bennett 2005). Delta Smelt were once regarded as one of the most common pelagic fish in the Delta, but declines in their population led to their listing under the ESA as threatened in 1993 (USFWS 2008a). Delta Smelt are one of four pelagic fish species (including Longfin Smelt, Threadfin Shad, and juvenile Striped Bass) documented to be in decline based on fall midwater trawl abundance indices (Sommer et al. 2007a). The causes of the declines have been extensively studied and are thought to include a combination of factors, such as decreased habitat quantity and quality, increased mortality rates, and reduced food availability (Feyrer et al. 2007, Sommer et al. 2007a, Moyle and Bennett 2008, Baxter et al. 2010, MacNally et al. 2010, Rose et al. 2013a, b, Sommer and Mejia 2013). Two statistical analyses that used similar data but different statistical methods, (MacNally et al. 2010; Thomson et al. 2010) examined the dynamics of the four fish species. Both analyses identified several covariates that were related to abundance of the fish, but they could not resolve the cause of the recent declines. The analysis of model results and data for 1995–2005 conducted by Rose et al. (2013a) indicated that it has been difficult to ascribe the Delta Smelt's decline to a single cause, either over the long term or as part of the recent 2002 decline.

The status of the Delta Smelt is uncertain, as indicators of Delta Smelt abundance have continued to decline and the number of fish collected in sampling programs, such as the trawl surveys conducted by the IEP, have dropped even lower in recent years. The Fall Midwater Trawl (FMWT) Survey is recognized by some as the best available long-term index of Delta Smelt relative abundance (USFWS 2008). Figure 9.1 presents the FMWT abundance indices for Delta Smelt from 1967 to 2013 (CDFW 2014b). Fewer than 10 Delta Smelt were collected in these surveys in 2014; the 2014 Delta Smelt index was 9, making it the lowest in FMWT history (CDFW 2014a, 2015). Results for Delta Smelt from the 2015 spring Kodiak trawl, 20-mm survey, and summer townet survey reported in the June 2015 Smelt Working Group meeting summary were similarly low (Smelt Working Group 2015).

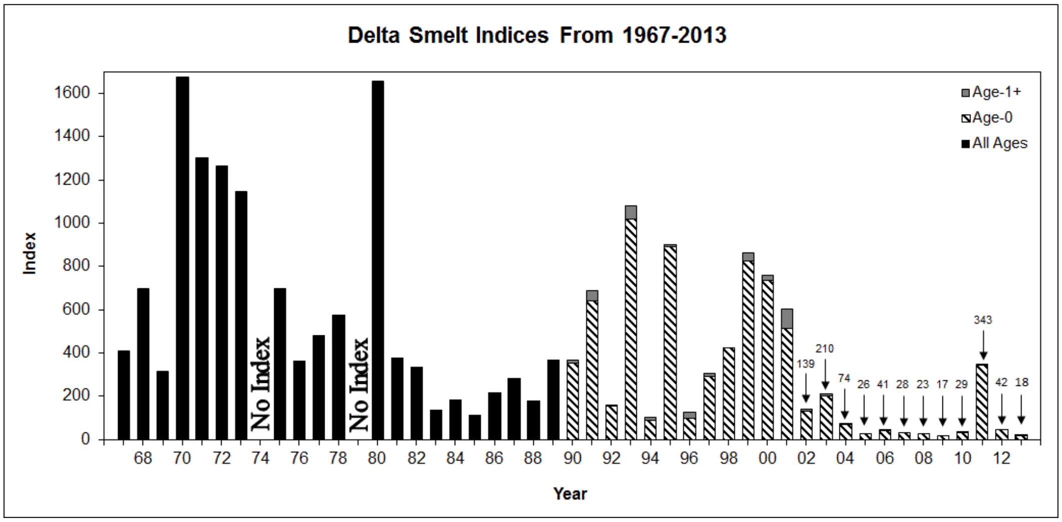

Figure 9.1 Fall Midwater Trawl Abundance Indices for Delta Smelt from 1967 to 2013

Source: California Department of Fish and Wildlife, Trends in Abundance of Selected Species, January 15, 2014. http://www.dfg.ca.gov/delta/data/fmwt/Indices/

Studies conducted to synthesize available information about Delta Smelt indicate that Delta Smelt have been documented throughout their geographic range during much of the year (Merz et al. 2011, Sommer and Mejia 2013, Brown et al. 2014). Studies indicate that in fall, prior to spawning, Delta Smelt are found in the Delta, Suisun and San Pablo bays, the Sacramento River and San Joaquin River confluence, Cache Slough, and the lower Sacramento River (Murphy and Hamilton 2013). By spring, they move to freshwater areas of the Delta region, including the Sacramento River and San Joaquin River confluence, the Upper Sacramento River, and Cache Slough (Brown et al. 2014, Murphy and Hamilton 2013).

Sommer et al. 2011 described that during winter, adult Delta Smelt initiate upstream spawning migrations in association with “first flush” freshets. Others report this seasonal change as a multi-directional and more circumscribed dispersal movement to freshwater areas throughout the Delta region (Murphy and Hamilton 2013). After arriving in freshwater staging habitats, adult Delta Smelt hold until spawning commences during favorable water temperatures in the late winter-spring (Bennett 2005, Grimaldo et al. 2009, Sommer et al. 2011). Delta Smelt spawn over a wide area throughout much of the Delta, including some areas downstream and upstream as conditions allow. Although the specific substrates or habitats used for spawning by Delta Smelt are not known, spawning habitat preferences of closely related species (Bennett 2005) suggest that spawning may occur in shallow areas over sandy substrates. The nonpelagic habitats used by larval Delta Smelt before they move into the pelagic areas also are not known (Swanson et al. 1998, Sommer et al. 2011).

During and after larval rearing in fresh water, many young Delta Smelt move with river and tidal currents to remain in favorable rearing habitats, often moving increasingly into the low salinity zone to avoid seasonally warm and highly transparent waters that typify many areas in the central Delta (Nobriga et al. 2008). Bennett and Burau (2014) showed that during winter, delta smelt aggregate near frontal zones at the shoal-channel interface moving laterally into the shoals on ebb tides and back into the channel on flood tides. They suggest that this migration strategy can minimize the energy spent swimming against strong river and tidal currents, as well as predation risks by remaining in turbid water.

During summer and fall, many juvenile Delta Smelt continue to grow and rear in the low salinity zone until maturing the following winter (Bennett 2005). Some Delta Smelt also rear in upstream areas such as the Cache Slough complex and Sacramento Deepwater Ship Channel, depending on habitat conditions (Sommer and Mejia 2013).

During summer and fall, the distribution of juvenile Delta Smelt rearing is influenced by the position of the low salinity zone (as indexed by the position of X2), although their distribution can also be influenced by temperature and turbidity (Bennett 2005; Feyrer et al. 2007, 2010; Kimmerer et al. 2009; Sommer and Mejia 2013). The geographical position of the low salinity zone varies primarily as a function of freshwater outflow; thus, X2 typically lies farther east in summer and fall during low outflow conditions and drier water years and farther west during high outflow conditions (Jassby et al. 1995).

Higher outflow causes X2 and the low salinity zone to more frequently overlap with the Suisun Bay/Marsh region, which is broader and shallower and typically has greater turbidity than the mainstem Sacramento and San Joaquin rivers. The overlap of the low salinity zone (or X2) with the Suisun Bay/Marsh results in a dramatic increase in the habitat index (Feyrer et al. 2010); however others (see Manly et al. 2015) have questioned the use by Feyrer et al. (2010) of outflow and X2 location as an indicator of Delta Smelt habitat because other factors may be influencing survival.

In addition to salinity, turbidity is an important factor associated with habitat use; Delta Smelt show a strong preference for higher turbidity water (Feyrer et al. 2007, 2010; Sommer and Mejia 2013) and turbidity may be a key habitat feature and cue initiating the delta smelt spawning migration (Bennett and Burau 2014). Turbidity has decreased in recent decades within the Delta (Kimmerer 2004, Schoellhamer 2011), which has likely contributed to declines in environmental quality of Delta Smelt habitat (Feyrer et al. 2007, 2010). Higher turbidities are believed to allow Delta Smelt to hide from open-water predators, such as Striped Bass (Gregory and Levings 1998, Nobriga et al. 2005), and contribute to feeding success (Lindberg et al. 2000, IEP 2015).

Water temperature is another important environmental factor that affects Delta Smelt habitat and population dynamics (Sommer and Mejia 2013). A longer period of optimal water temperatures in cooler years increases the number of spawning events and cohorts produced (Bennett 2005). During rearing, summer water temperatures also have been shown to be an important predictor of Delta Smelt occurrence, based on multi-decadal analyses of summer tow net survey data (Nobriga et al. 2008).

The quality and availability of food also have important effects on the abundance and distribution of Delta Smelt (Sommer and Mejia 2013, Kimmerer 2008). Delta Smelt feed primarily on zooplankton, and Nobriga (2002) showed that Delta Smelt larvae with food in their guts typically co-occurred with higher calanoid copepod densities. Food quality and availability have varied substantially, largely because of the history of nonnative species introduction into the San Francisco Estuary (Baxter et al. 2008, Winder and Jassby 2011). The decline of zooplankton in the western Delta has been hypothesized to be related to several factors, including increased ammonium concentrations from wastewater effluent and agricultural runoff (Wilkerson et al. 2006; Dugdale et al. 2007; Miller et al. 2012; Glibert 2010; Glibert et al. 2011, 2014).

In 2011 and 2012, an unanticipated change in water management operations led to relatively large phytoplankton blooms in the western Delta, including in the Sacramento River near Rio Vista. Historically, rice fields along the Colusa Basin Drain are flooded in fall to decompose the rice stubble, and the water is released through the Knights Landing Outfall gates into the Sacramento River. In 2011 and 2012, construction at the outfall gates required the water to be diverted into the Yolo Bypass, resulting in higher than normal flows. These events temporarily resulted in a fall pulse flow in the Yolo Bypass that increased the volume of flow by more than 300 to 900 percent (Frantzich 2014). Concurrently, a substantial increase in nutrients, phytoplankton, and zooplankton was observed in the Yolo Bypass and Cache Slough. In 2013, the fall pulse flow of rice drainage water did not occur in the Yolo Bypass, and nutrient concentrations did not increase. These nutrient inputs, when they occur, and corresponding increases in phytoplankton and zooplankton production, could contribute to improved foraging opportunities for Delta Smelt.

Results in prior years indicate that entrainment and salvage-related mortality of Delta Smelt associated with water pumping and CVP/SWP exports from the Delta occur primarily from December to July (Kimmerer 2008, Grimaldo et al. 2009, Baxter et al. 2010). Entrainment occurs when migrating and spawning adult Delta Smelt and their larvae overlap in time and space with reverse (southward, or upstream) flows in the Old and Middle river channels (Kimmerer 2008, Grimaldo et al. 2009, Baxter et al. 2010).

In January 2015, the IEP Management Analysis and Synthesis Team (MAST) published a report to provide an assessment and conceptual model of factors affecting Delta Smelt throughout its life cycle. One focus of the report was an evaluation of a notable increase in abundance of all Delta Smelt life stages in 2011, which indicated that the Delta Smelt population could potentially rebound when conditions are favorable for spawning, growth, and survival.

The IEP MAST updated conceptual model described the habitat conditions and ecosystem drivers affecting each Delta Smelt life stage, across seasons and how the seasonal effects contributed to the annual success of the species. The conclusions of the report highlighted some key points about Delta Smelt and their habitat, using 2011 as the example year. In summary, the report concluded that Delta Smelt likely benefitted from the following favorable habitat conditions in 2011:

1) Adults and larvae benefitted from high winter 2010 and spring 2011 outflows, which reduced entrainment risk and possibly improved other habitat conditions, prolonged cool spring water temperatures, and possibly good food availability in late spring.

2) Juvenile Delta Smelt benefitted from cool water temperatures in late spring and early summer as well as from relatively good food availability and low levels of harmful Microcystis.

3) Subadults benefitted from good food availability and from favorable habitat conditions in the large low salinity zone, located more toward Suisun Bay in 2010.

Longfin Smelt

Longfin Smelt populations occur along the Pacific Coast of North America, and the San Francisco Estuary represents the southernmost population. Longfin Smelt generally occur in the Delta; Suisun, San Pablo, and San Francisco bays; and the Gulf of the Farallones, just outside San Francisco Bay. Longfin Smelt are not a focus of any specific RPA actions. However, RPA actions that benefit Delta Smelt, salmonids, and sturgeon, including increasing Delta outflow, have the potential to benefit other fish, including Longfin Smelt, given their similar habitat requirements and trophic feeding levels.

Longfin Smelt are anadromous and spawn in fresh water in the Delta, generally at 2 years of age (Moyle 2002). They migrate upstream to spawn during late fall through winter, with most spawning from November through April (DFG 2009a). Spawning in the Sacramento River is believed to occur from just downstream of the confluence of the Sacramento and San Joaquin rivers upstream to about Rio Vista. Spawning on the San Joaquin River extends from the confluence upstream to about Medford Island (Moyle 2002). Spawning likely also occurs in Suisun Marsh and the Napa River (DFG 2009a).

Longfin Smelt larvae are most abundant in the water column usually from January through April (Reclamation 2008a). The geographic distribution of Longfin Smelt larvae is closely associated with the position of X2; the center of distribution varies with outflow conditions, but not with respect to X2 (Dege and Brown 2004). This pattern is consistent with juveniles migrating downstream to low salinity, brackish habitats for growth and rearing. Larger Longfin Smelt feed primarily on opossum shrimps and other invertebrates (Feyrer et al. 2003). Copepods and other crustaceans also can be important food items, especially for smaller fish (Reclamation 2008a).

Longfin Smelt in the San Francisco Estuary are broadly distributed in both time and space, and interannual distribution patterns are relatively consistent (Rosenfield and Baxter 2007). Seasonal patterns in abundance indicate that the population is at least partially anadromous (Rosenfield and Baxter 2007), and the detection of Longfin Smelt within the estuary throughout the year suggests that, similar to Striped Bass, anadromy is one of several life history strategies or contingents in this population.

The relative population size of Longfin Smelt in the San Francisco Estuary is measured by indices of abundance generated from different sampling programs. The abundance of age 0 and older fish is best indexed by the Fall Midwater Trawl and Bay Study, while the abundance of larvae and young juveniles is best indexed by the 20-mm survey. The relationship between these indices and actual population sizes is unknown. Although the Fall Midwater Trawl data suggest a sharp decline in Longfin Smelt abundance during the last decade, some of that decline might be attributable to a downstream movement in the longfin distribution into regions better covered by the Bay Study fish survey. The Bay Study uses two types of trawls, an otter trawl and a midwater Trawl. The Longfin Smelt abundance index created from the Fall Midwater Trawl is consistent with the trend in the Bay Study midwater trawl but not the Bay Study otter Trawl. In addition, there have been an increasing proportion of false zeros in the survey data where the Bay Study midwater trawl failed to detect any Longfin Smelt when they were detected in the otter trawl.

The abundance of Longfin Smelt in the estuary has fluctuated over time but has exhibited statistically significant step-declines around 1989 to 1991 and in 2004 (Thomson et al. 2010). A synthesis of prior studies conducted by USFWS in its 12-Month Finding on a Petition to List the San Francisco Bay-Delta Population of the Longfin Smelt as Endangered or Threatened (USFWS 2012) reported that increased Delta outflow in winter and spring is the largest factor possibly affecting Longfin Smelt abundance. The trend in Longfin Smelt abundance from 1967 through 2013 is presented on Figure 9.2.

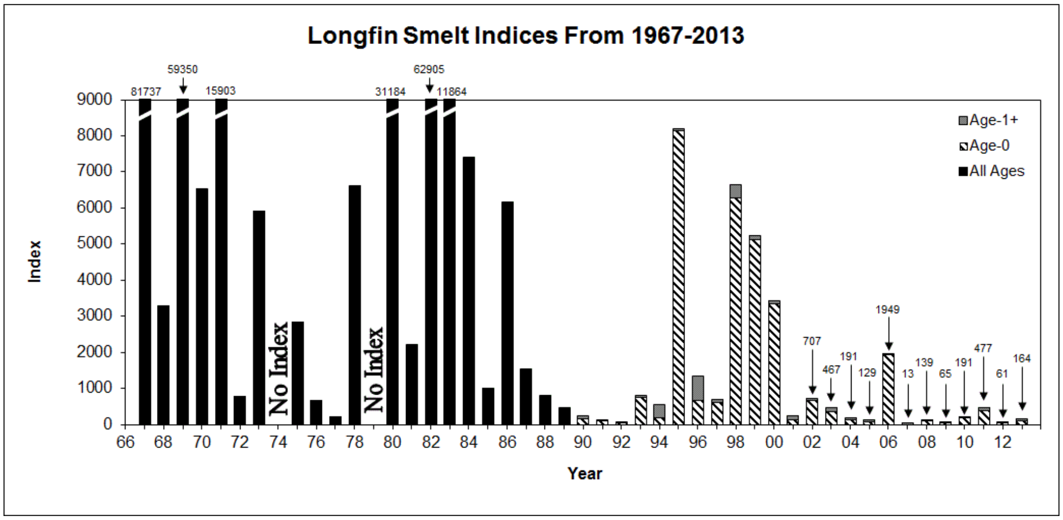

Figure 9.2 Fall Midwater Trawl Abundance Indices for Longfin Smelt from 1967 to 2013

Source: California Department of Fish and Wildlife, Trends in Abundance of Selected Species, January 15, 2014. http://www.dfg.ca.gov/delta/data/fmwt/Indices/

Habitat for Longfin Smelt is open water, largely away from shorelines and vegetated inshore areas except perhaps during spawning. This includes all of the large embayments in the estuary and the deeper areas of many of the larger channels in the western Delta; habitat suitability in these areas for Longfin Smelt can be strongly influenced by variation in freshwater flow (Jassby et al. 1995, Bennett and Moyle 1996, Kimmerer 2004, Kimmerer et al. 2009).

Water exports and inadvertent entrainment at the SWP and CVP export facilities are anthropogenic sources of mortality for Longfin Smelt. The export facilities are known to entrain most species of fish in the Delta (Brown et al. 1996). Longfin Smelt entrainment mainly occurs from December to May, with peak adult entrainment from December to February (Grimaldo et al. 2009). In water year 2011, Aasen (2012) reported four adult Longfin Smelt were salvaged at the project export facilities, compared with much higher numbers in the early 2000s and late 1980s. The entrainment of Longfin Smelt in recent years has been reduced likely because of changes in export operations and a decline in abundance.

Sacramento Splittail

Sacramento Splittail are found primarily in marshes, turbid sloughs, and slow-moving river reaches throughout the Delta subregion (Sommer et al. 1997, 2008). Sacramento Splittail are most abundant in moderately shallow, brackish tidal sloughs and adjacent open-water areas, but they also can be found in freshwater areas with tidal or riverine flow (Moyle et al. 2004).

Adult Sacramento Splittail typically migrate upstream from brackish areas in January and February and spawn in fresh water, particularly on inundated floodplains when they are available, in March and April (Sommer et al. 1997, Moyle et al. 2004, Sommer et al. 2008). A substantial amount of splittail spawning occurs in the Yolo and Sutter bypasses and the Cosumnes River area of the Delta (Moyle et al. 2004). Spawning also can occur in the San Joaquin River during high-flow events (Sommer et al. 1997, 2008). However, not all adults migrate significant distances to spawn as evidenced by spawning in the Napa and Petaluma rivers (Feyrer et al. 2005).

Although juvenile Sacramento Splittail are known to rear in upstream areas for a year or more (Baxter 1999), most move to the Delta after only a few weeks or months of rearing in floodplain habitats along the rivers (Feyrer et al. 2006). Juveniles move downstream into the Delta from April to August (Meng and Moyle 1995, Feyrer et al. 2005). Sacramento Splittail recruitment is largely limited by extent and period of inundation of floodplain spawning habitats, with abundance observed to spike following wet years and dip after dry years (Moyle et al. 2004). However, the 5- to 7-year life span buffers the adult population abundance (Sommer et al. 1997, Moyle et al. 2004). Other factors that may adversely affect the splittail population in the Delta include entrainment, predation, changed estuarine hydraulics, nonnative species (Moyle et al. 2004), pollutants (Greenfield et al. 2008), and limited food.

American Shad

American Shad is a recreationally important anadromous species introduced into the Sacramento-San Joaquin River Basin in the 1870s (Moyle 2002). American Shad spend most of their adult life at sea and may make extensive migrations along the coast. American Shad become sexually mature while in the ocean and migrate through the Delta to spawning areas in the Sacramento, Feather, American, and Yuba rivers. Some spawning also takes place in the lower San Joaquin, Mokelumne, and Stanislaus rivers (USFWS 1995). The spawning migration may begin as early as February, but most adults migrate into the Delta in March and early April (Skinner 1962). Migrating adults generally take 2 to 3 months to pass through the Sacramento-San Joaquin estuary (Painter et al. 1979).

Fertilized eggs are slightly negative buoyant, are not adhesive, and drift in the current. Newly hatched larvae are found downstream of spawning areas and can be rapidly transported downstream by river currents because of their small size. Juvenile shad rear in the Sacramento River below Knights Landing, the Feather River below Yuba City, and the Delta; rearing also takes place in the Mokelumne River near the DCC to the San Joaquin River. No rearing occurs in the American and Yuba rivers (Painter et al. 1979). Some juvenile shad may rear in the Delta for up to a year before outmigrating to the ocean (USFWS 1995). Outmigration from the Delta begins in late June and continues through November (Painter et al. 1979).

Juvenile American Shad are frequently encountered in the Delta during the FMWT Survey and in fish salvage monitoring at the south Delta SWP and CVP fish facilities (DWR et al. 2013). American Shad use of the Delta has been observed to vary with salinity (e.g., X2 position) and outflows (Kimmerer 2002).

American Shad are entrained at the Tracy Fish Collection Facility (Bowen et al. 1998) and in the Clifton Court Forebay, mostly during May through December when young American Shad migrate downstream. The American Shad population in the Sacramento-San Joaquin River Basin has declined since the late 1970s, most likely because of increased diversion of water from rivers and the Delta, combined with changing ocean conditions, and possibly pesticides (Moyle 2002). Salvage of American Shad at project export facilities in water year 2011 represented nearly 659,000 fish (Aasen 2012), with similar but slightly lower salvage in 2010 (545,125 fish) (Aasen 2011).

Striped Bass

Striped Bass is a recreationally important anadromous species introduced into the Sacramento-San Joaquin River Basin between 1879 and 1882 (Moyle 2002). Despite their nonnative status and piscivorous feeding habits, Striped Bass are considered important because they are a major game fish in the Delta. Striped Bass use the Delta as a migratory route and for rearing and seasonal foraging. Striped Bass spend the majority of their lives in salt water, returning to fresh water to spawn. When not migrating for spawning, adult Striped Bass in the San Francisco Bay-Delta are found in San Pablo Bay, San Francisco Bay, and the Pacific Ocean (Moyle 2002). Adult Striped Bass spend about 6 to 9 months of the year in San Francisco and San Pablo bays (Hassler 1988). Striped Bass also use deeper areas of many of the larger channels in the Delta, in addition to large embayments such as Suisun Bay.

Spawning occurs in spring, primarily in the Sacramento River between Sacramento and Colusa and in the San Joaquin River between Antioch and Venice Island (Farley 1966). Eggs are free-floating and negatively buoyant and hatch as they drift downstream, with larvae occurring in shallow and open waters of the lower reaches of the Sacramento-San Joaquin rivers, the Delta, Suisun Bay, Montezuma Slough, and Carquinez Strait. According to Hassler (1988), the distribution of larvae in the estuary depends on river flow. In low-flow years, all Striped Bass eggs and larvae are found in the Delta, while in high-flow years, the majority of eggs and larvae are transported downstream into Suisun Bay.

YOY Striped Bass distribute themselves in accordance with the estuarine salinity gradient (Kimmerer 2002, Feyrer et al. 2007), indicating that salinity is a major factor affecting their habitat use and geographic distributions. Kimmerer (2002) found that distributions of fish species, including Striped Bass, substantially overlapped with the low salinity zone. Older Striped Bass are increasingly flexible about their distribution relative to salinity (Moyle 2002).

The entrainment of Striped Bass has been observed at the project export facilities, including Clifton Court Forebay (Stevens et al. 1985, Bowen et al. 1998, Aasen 2012). In water year 2011, salvage of Striped Bass at export facilities (approximately 550,000 fish) continued a generally low trend observed since the mid-1990s. Prior to 1995, annual Striped Bass salvage was generally above 1 million fish (Aasen 2012). DWR et al. (2013) reported that Striped Bass longer than 24 mm were effectively screened at Tracy Fish Collection Facility and bypassed the pumps. However, planktonic eggs, larvae, and juveniles smaller than 24 mm in length received no protection from entrainment.

Striped Bass, primarily YOY, are one of the pelagic fish of the upper estuary that have shown substantial variability in their populations, with evidence of long-term declines (Kimmerer et al. 2000, Sommer et al. 2007a). As discussed earlier for Delta Smelt, a substantial portion of the abundance patterns has been associated with variation of outflow in the estuary (Jassby et al. 1995, Kimmerer et al. 2001, Loboschefsky et al. 2012), although this is disputed by some stakeholders (Bourez 2011). However, surveys showed that population levels for YOY Striped Bass began to decline sharply around 1987 and 2002 (Thomson et al. 2010), despite relatively moderate hydrology, which typically supports at least modest fish production (Sommer et al. 2007a). Moyle (2002) cites causes of decline in Striped Bass to include climatic factors, entrainment at project export facilities in the south Delta, other diversions, pollutants, reduced estuarine productivity, invasions by alien species, and human exploitation. Kimmerer et al. (2000, 2001) attribute the decline in juvenile YOY Striped Bass to declining carrying capacity, likely related to food limitation. Loboschefsky et al. (2012) showed that there had been no long-term decline for age 1 and older Striped Bass as of 2004.

Pacific Lamprey

The Pacific Lamprey is a widely distributed species that uses the Delta for upstream migration as adults, for downstream migration as juveniles, and for rearing as ammocoetes (larval form) (Hanni et al. 2006, Moyle et al. 2009). Pacific Lampreys are present in the north, central, and south Delta, and ammocoetes are present year-round in all of the regions (DWR et al. 2013). Limited information on status of Pacific Lamprey in the Delta exists, but the number of lampreys inhabiting the Delta is likely greatly suppressed compared with historical levels, as suggested by the loss of access to historical habitat and apparent population declines throughout California and the Sacramento-San Joaquin River Basin (Moyle et al. 2009).

Limited data indicate most adult Pacific Lamprey migrate though the Delta enroute to upstream holding and spawning grounds in the early spring through early summer (Hanni et al. 2006). As documented in other large river systems, it is likely that some adult migration through the Delta occurs from late fall and winter through summer and possibly over an even broader period (Robinson and Bayer 2005, Hanni et al. 2006, Moyle et al. 2009, Clemens et al. 2012, Lampman 2011). Data from the FMWT Survey in the lower Sacramento and San Joaquin rivers and Suisun Bay suggest that peak outmigration of Pacific Lamprey through the Delta coincides with high-flow events from fall through spring (Hanni et al. 2006). Some outmigration likely occurs year-round, as observed at sites farther upstream (Hanni et al. 2006), and in other river systems (Moyle 2002). Some Pacific Lamprey ammocoetes likely spend part of their extended (5 to 7 years) freshwater residence rearing in the Delta, particularly in the upstream, freshwater portions (DWR et al. 2013).

9.3.4.12.2 Aquatic Habitat

Flow management in the Delta has created stress on aquatic resources by (1) changing aspects of the historical flow regime (timing, magnitude, duration) that supported life history traits of native species; (2) limiting access to or quality of habitat; (3) contributing to conditions better suited to invasive, nonnative species (reduced spring flows, increased summer inflows and exports, and low and less-variable interior Delta salinity [Moyle and Bennett 2008]); and (4) causing reverse flows in channels leading to project export facilities that can entrain fish (Mount et al. 2012). Native species of the Delta are adapted to and depend on variable flow conditions at multiple scales as influenced by the region's dramatic seasonal and interannual climatic variation. In particular, most native fishes evolved reproductive or outmigration timing associated with historical peak flows during spring (Moyle 2002).

Water temperatures in the Delta follow a seasonal pattern of winter cold-water conditions and summer warm-water conditions, largely because of the region's Mediterranean climate, with alternating cool-wet and hot-dry seasons. Currently in the Delta, the most significant changes in water temperatures have been in the form of increased summer water temperatures over large areas of the Delta because of high summer ambient air temperatures, the increased temperature of river inflows, and to a lesser extent, reduced quantities of freshwater inflow and modified tidal and groundwater hydraulics (Kimmerer 2004, Mount et al. 2012, NRC 2012, Wagner et al. 2011). Water temperatures in summer now approach or exceed the upper thermal tolerances (e.g., 20 to 25° Centigrade [C]) for cold-water fish species such as salmonids and Delta-dependent species such as Delta Smelt. This is especially true in parts of the south Delta and San Joaquin River, potentially restricting the distribution of these species and precluding previously important rearing areas (NRC 2012).

Landscape-scale changes resulting from flood management infrastructure, along with flow modification, have eliminated most of the historical hydrologic connectivity of floodplains and aquatic ecosystems in the Delta and its tributaries, thereby degrading and diminishing Delta habitat for native plant and animal communities (Mount et al. 2012). The large reduction of hydrologic variability and landscape complexity, coupled with degradation of water quality, has supported invasive aquatic species that have further degraded conditions for native species. Due to the combination of these factors, the Delta appears to have undergone an ecological regime shift unfavorable to many native species (Moyle and Bennett 2008, Baxter et al. 2010). The major species influenced by current Delta hydrology include Delta Smelt, Longfin Smelt, Sacramento Splittail, White Sturgeon, juvenile Chinook Salmon, and Striped Bass (Jassby et al. 1995, Kimmerer 2002, Rosenfield and Baxter 2007, Kimmerer et al. 2009, Fish 2010, Perry et al. 2012, Thomson et al. 2010, Feyrer et al. 2010, Loboschefsky et al. 2012, Mount et al. 2012).

Salinity is a critical factor influencing plant and animal communities in the Delta. Although estuarine fish species are generally tolerant of a range of salinity, this varies by species and lifestage. Some species can be highly sensitive to excessively low or high salinity during physiologically vulnerable periods, such as reproductive and early life history stages. Although the Delta is tidally influenced, most of the Delta is fresh water year-round, due to inflows from rivers. The south Delta can have low salinity because of agricultural return water. The tidally influenced low salinity zone can move upstream into the central Delta.

An important measure of the spatial geography of salinity in the western Delta is X2. The X2 has also been correlated with the amount of suitable habitat for Delta Smelt in fall (Feyrer et al. 2007, 2010; USFWS 2008a). It is also helps define the extent of habitat available for oligohaline pelagic organisms and their prey. An analysis of historical monitoring data by Feyrer et al. (2007) revealed that the abiotic habitat of Delta Smelt can be defined as a specific envelope of salinity and turbidity that changes over the course of the species' life cycle. Project operations and other potential factors (e.g., lower outflows) have tended to shift the X2 position in fall farther upstream out of the wide expanse of Suisun Bay into the much narrower channels near the confluence of the Sacramento and San Joaquin rivers (near Collinsville), reducing the spatial extent of low salinity habitat important for relevant species such as Delta Smelt (USFWS 2008a, 2011a; Kimmerer et al. 2009; Baxter et al. 2010). However, there is emerging information suggesting that a comparison of the Delta outflow during pre-project and post-project time periods do not support the conclusion that project operations have significantly moved X2 more easterly in September and October compared to pre-project conditions and project operations have only potentially impacted X2 location in November (Hutton et al. in press).

9.3.4.12.3 Nutrients and Food Web Support

Nutrients are essential components of terrestrial and aquatic environments because they provide a resource base for primary producers. Typically in freshwater aquatic environments, phosphorous is the primary limiting macronutrient, whereas in marine aquatic environments, nitrogen tends to be limiting. A balanced range of abundant nutrients provides optimal conditions for maximum primary production, a robust food web, and productive fish populations. However, changes in nutrient loadings and forms, excessive amounts of nutrients, and altered nutrient ratios can lead to eutrophication and a suite of problems in aquatic ecosystems, such as low dissolved oxygen concentrations, un-ionized ammonia, excessive growth of toxic forms of cyanobacteria, and changes in components of the food web. Nutrient concentrations in the Delta have been well studied (Jassby et al. 2002; Kimmerer 2004; Van Nieuwenhuyse 2007; Glibert 2010; Glibert et al. 2011, 2014).

Estuaries are commonly characterized as highly productive nursery areas for numerous aquatic organisms. Nixon (1988) noted that there is a broad continuum of primary productivity levels in different estuaries, which in turn affects fish production and abundance. Compared to other estuaries, pelagic primary productivity in the upper San Francisco Estuary is relatively poor, and a relatively low fish yield is expected (Wilkerson et al. 2006). In the Delta and Suisun Marsh, this appears to result from turbidity, clam grazing (Jassby et al. 2002), and nitrogen and phosphorus dynamics (Wilkerson et al. 2006, Van Nieuwenhuyse 2007, Glibert 2010, Glibert et al. 2014).

There has been a significant long-term decline in phytoplankton biomass (chlorophyll a) and primary productivity to low levels in the Suisun Bay region and the Delta (Jassby et al. 2002). Shifts in nutrient concentrations such as high levels of ammonium and nitrogen to phosphorus ratio may contribute to the phytoplankton reduction and to changes in algal species composition in the San Francisco Estuary (Wilkerson et al. 2006; Dugdale et al. 2007; Lehman et al. 2005, 2008b, 2010; Glibert 2010; Glibert et al. 2014). Low and declining primary productivity in the estuary may be contributing to the long-term pattern of relatively low and declining biomass of pelagic fishes (Jassby et al. 2002).

The introductions of two clams from Asia have led to major alterations in the food web in the Delta. *Potamocorbula* is most abundant in the brackish and saline water of Suisun Bay and the western Delta, and *Corbicula* is most abundant in the fresh water of the central Delta. These filter feeders significantly reduce the phytoplankton and zooplankton concentrations in the water column, reducing food availability for native fishes, such as Delta Smelt and young Chinook Salmon (Feyrer et al. 2007, Kimmerer 2002).

Additionally, introduction of the clams led to the decline of higher-food-quality native copepods and the establishment of poorer quality nonnative copepods. More recently, the cyclopoid copepod, *Limnoithona*, has rapidly become the most abundant copepod in the Delta after its introduction in 1993 (Hennessy and Enderlein 2013). This species is hypothesized to be a low-quality food source and intraguild predator of native and nonnative calanoid copepods (CRA 2005). The clam *Potamocorbula* also has been implicated in the reduction of the native opossum shrimp, a preferred food of Delta native fishes such as Sacramento Splittail and Longfin Smelt (Feyrer et al. 2003). Reductions in food availability and food quality have led to lower fish foraging efficiency and reduced growth rates (Moyle 2002).

Studies on food quality have been relatively limited in the San Francisco Estuary, with even less information on long-term trends. Nonetheless, several studies have documented or suggested the food limitations for aquatic species in the estuary, including zooplankton (Mueller-Solger et al. 2002, Kimmerer et al. 2005), Delta Smelt (Bennett 2005, Bennett et al. 2008), Chinook Salmon (Sommer et al. 2001a), Sacramento Splittail (Greenfield et al. 2008), Striped Bass (Loboschefsky et al. 2012), and Largemouth Bass (Nobriga 2009).

9.3.4.12.4 Turbidity

Turbidity is an important water quality component in the Delta that affects physical habitat through sedimentation and food web dynamics through attenuation of light in the water column. Light attenuation, in turn, affects the extent of the photic zone where primary production can occur and the ability of predators to locate prey and for prey to escape predation.

Turbidity has been declining in the Delta, as indicated by sediment data collected by the U.S. Geological Survey since the 1950s (Wright and Schoellhamer 2004), with important implications for food web dynamics and predation. Higher water clarity is at least partially caused by increased water filtration and plankton grazing by highly abundant overbite clams (*Potamocorbula amurensis*) and other benthic organisms (Kimmerer 2004, Greene et al. 2011). High nutrient loads, coupled with reduced sediment loads and higher water clarity, could contribute to plankton and algal blooms and overall increased eutrophic conditions in some areas (Kimmerer 2004).

The first high-flow events of winter create turbid conditions in the Delta, which can be drawn into the south Delta during reverse flow conditions in the Old and Middle rivers. Delta Smelt may follow turbid waters into the southern Delta, increasing their proximity to project export facilities and, therefore, their entrainment risk (USFWS 2008a).

9.3.4.12.5 Contaminants

Contaminants can change ecosystem functions and productivity through numerous pathways. Trends in contaminant loadings and their ecosystem effects are not well understood. Efforts are underway to evaluate direct and indirect toxic effects on the POD fishes of manmade contaminants and natural toxins associated with blooms of *Microcystis aeruginosa*, a cyanobacterium or blue-green alga that releases a potent toxin known as microcystin. Toxic microcystins cause food web impacts at multiple trophic levels, and histopathological studies of fish liver tissue suggest that fish exposed to elevated concentrations of microcystins have developed liver damage and tumors (Lehman et al. 2005, 2008b, 2010.)

There are longstanding concerns related to mercury and selenium in the Sacramento and San Joaquin watersheds, the Delta, and San Francisco Bay (see Chapter 6, Surface Water Quality, for additional detail on these constituents). Additional study is needed to avoid increases in mercury exposure resulting from tidal wetlands restoration; methylmercury is produced at a relatively high rate in wetlands and newly flooded aquatic habitats (Davis et al. 2003). Methylmercury increases in concentration at each level in the food chain and can cause concern for people and birds that eat piscivorous fish (bass) and sturgeon, as described in Chapter 6, Surface Water Quality. It has not been shown to be a direct problem for fish in the Delta, but studies of other fish summarized by Alpers et al. (2008) indicate that mercury in fish has been linked to hormonal and reproductive effects, liver necrosis, and altered behavior in fish. With regard to selenium, benthic foragers like diving ducks, sturgeon, and splittail have the greatest risk of selenium toxicity; the invasion of the nonnative bivalves (e.g., *P. amurensis*) has resulted in increased bioavailability of selenium to benthivores in San Francisco Bay (Linville et al. 2002).

Baxter et al. (2008) prepared a 2007 synthesis of results as part of a POD Progress Report, including a summary of prior studies of contaminants in the Delta. The summary included studies that suggested that phytoplankton growth rates may be inhibited by localized high concentrations of herbicides (Edmunds et al. 1999).

Toxicity to invertebrates has been noted in water and sediments from the Delta and associated watersheds (Kuivila and Foe 1995, Weston et al. 2004). The 2004 Weston study of sediment toxicity recommended additional study of the effects of the pyrethroid insecticides on benthic organisms. Undiluted drainwater from agricultural drains in the San Joaquin River watershed can be acutely toxic (quickly lethal) to fish (Chinook Salmon and Striped Bass) and have chronic effects on growth, likely because of high concentrations of major ions (e.g., sodium and sulfates) and trace elements (e.g., chromium, mercury, and selenium) (Saiki et al. 1992).

9.3.4.12.6 Fish Passage and Entrainment

The Delta presents a challenge for anadromous and resident fish during upstream and downstream migration, with its complex network of channels, low eastern and southern tributary inflows, and reverse currents created by pumping for water exports. These complex conditions can lead to straying, extended exposure to predators, and entrainment during outmigration. Tidal elevations, salinity, turbidity, in-flow, meteorological conditions, season, habitat conditions, and project exports all have the potential to influence fish movement, currents, and ultimately the level of entrainment and fish passage success and survival, which is the subject of extensive research and adaptive management efforts (IRP 2010, 2011). Michel et al. (2010, 2015) used acoustic telemetry to examine survival of late fall-run Chinook Salmon smolts outmigrating from the Sacramento River through the Delta and San Francisco Estuary. Survival was lowest in the freshwater portion (Delta) and the brackish portion of the estuary relative to survival in the riverine portion of the migration route.

North Delta Fish Passage and Entrainment

In the north Delta, migrating fish have multiple potential pathways as they move upstream into the Sacramento or Mokelumne river systems. Marston et al. (2012) studied stray rates for in-migrating San Joaquin River Basin adult salmon that stray into the Sacramento River Basin. Results indicated that it was unclear whether reduced San Joaquin River pulse flows or elevated exports caused increased stray rates. The DCC, when open, can divert fish as they outmigrate along this route. The opening of the DCC when salmon are returning to spawn to the Mokelumne and Cosumnes rivers is believed to lead to increased straying of these fish into the American and Sacramento rivers because of confusion over olfactory cues. In recent years, experimental DCC closures have been scheduled during the fall-run Chinook Salmon migration season for selected days, coupled with pulsed flow releases from reservoirs on the Mokelumne River, in an attempt to reduce straying rates of returning adults. These closures have corresponded with reduced recoveries of Mokelumne River hatchery fish in the American River system and increased returns to the Mokelumne River hatchery (EBMUD 2012).

Outmigrating juvenile fish moving down the mainstem Sacramento River also can enter the DCC when the gates are open and travel through the Delta via the Mokelumne and San Joaquin river channels. In the case of juvenile salmonids, this shifted route from the north Delta to the central Delta increases their mortality rate (Kjelson and Brandes 1989, Brandes and McLain 2001, Newman and Brandes 2010, Perry et al. 2010, 2012). Steel et al. (2012) found that the best predictor of which route was selected was the ratio of mean water velocity between the two routes. Salmon migration studies show losses of approximately 65 percent for groups of outmigrating fish that are diverted from the mainstem Sacramento River into the waterways of the central and southern Delta (Brandes and McLain 2001; Vogel 2004, 2008; Perry and Skalski 2008). Perry and Skalski (2008) found that, by closing the DCC gates, total through-Delta survival of marked fish to Chipps Island increased by nearly 50 percent for fish moving downstream in the Sacramento River system. Closing the DCC gates appears to redirect the migratory path of outmigrating fish into Sutter and Steamboat sloughs and away from Georgiana Slough, resulting in higher survival rates. Species that may be affected include juvenile Green Sturgeon, steelhead, and winter and spring-run Chinook Salmon (NMFS 2009a).

However, analysis by Perry et al. (2015) suggests that the mechanisms governing route selection are more complex. Their analysis revealed the strong influence of tidal forcing on the probability of fish entrainment into the interior Delta. The probability of entrainment into both Georgiana Slough and the Delta Cross Channel was highest during reverse-flow flood tides, and the probability of fish remaining in the Sacramento River was near zero during flow reversals (Perry et al. 2015). The magnitude and duration of reverse flows at this river junction decrease as inflow of the Sacramento River increases. Consequently, reduced Sacramento River inflow increases the frequency of reverse flows at this junction, thereby increasing the proportion of fish that are entrained into the interior Delta, where mortality is high (Perry 2010).

Fish passage in the north Delta also can be affected by water quality. Water quality in the mainstem Sacramento River and its distributary sloughs can be poor at times during summer, creating conditions that may stress migrating fish or even impede migration. These conditions include dissolved oxygen, water temperatures, and, for some species, salinity (e.g., Delta Smelt). For adult Chinook Salmon, dissolved oxygen concentration less than 3 to 5 milligrams per liter (mg/L) can impede migration (Hallock et al. 1970) as can mean daily water temperatures of 21 to 23°C, depending on whether water temperatures are rising or falling (Strange 2010). Dissolved oxygen levels are generally >5 mg/L throughout the Delta, but water temperatures can exceed these thresholds during summer and fall.

The SWP Barker Slough Pumping Plant, located on a tributary to Cache Slough, may cause larval fish entrainment. The intake is equipped with a positive barrier fish screen to prevent fish at least 25 mm in size from being entrained. CDFW has monitored entrainment of larval Delta Smelt less than 20 mm at Barker Slough since 1995. When the presence of Delta Smelt larvae is indicated, pumping rates from Barker Slough are reduced to a 5-day running average rate of 65 cfs, not to exceed a 75-cfs daily average for any day, for a minimum of 5 days and until monitoring shows no Delta Smelt are present.

Central and South Delta Fish Passage and Entrainment

The south Delta intake facilities include the CVP and SWP export facilities; local agency intakes, including Contra Costa Water District intakes; and agricultural intakes. Contra Costa Water District intakes and the CVP Contra Costa Canal Pumping Plant include fish screens; however, most of the remaining intakes do not include fish screens. Water flow patterns in the south Delta are influenced by the water diversion actions and operations of the south Delta seasonal temporary barriers and tides and river inflows to the Delta (Kimmerer and Nobriga 2008). Delta diversions can create reverse flows, drawing fish toward project facilities (Arthur et al. 1996, Kimmerer 2008, Grimaldo et al. 2009). While swimming through southern Delta channels, fish can be subjected to stress from poor water quality (seasonally high temperatures, low dissolved oxygen, high water transparency, and *Microcystis* blooms) and slow water velocities in lake-like habitats. Any of these factors can cause elevated mortality rates by weakening or disorienting the fish and increasing their vulnerability to predators (Vogel 2011).

Cunningham et al. (2015) found a negative influence of the export/inflow ratio on the survival of fall-run Chinook populations and a negative influence of increased total Delta exports on the survival of spring-run Chinook populations. An increase in total exports of 1 standard deviation (SD) from the 1967 to 2010 average was predicted to result in a 68.1 percent reduction in the survival of Deer, Mill, and Butte Creek spring-run Chinook. Similarly, an increase in the ratio of Delta water exports to Delta inflow of 1 SD was expected to reduce survival of the four fall-run populations by 57.8 percent (Cunningham et al. 2015). Although a mechanistic explanation for the reduction in survival remains elusive, "*direct entrainment mortality seems an unlikely mechanism given the success of reclamation and transport procedures, even given increased predation potential at the release site. Changes to water routing may provide a more reasonable explanation for the estimated survival influence of Delta water exports*" (Cunningham et al. 2015). Although not directly comparable, this contrasts with the results of Zeug and Cavallo (2012) that found there was little evidence that large-scale water exports or inflows influenced CWT recovery rates in the ocean from 1993 to 2003.

Delaney et al. (2014) reported on a mark-recapture experiment examining the survival and movement patterns of acoustically tagged juvenile steelhead emigrating through the central and southern Delta. Their results indicated that most tagged steelhead remained in the mainstem San Joaquin River (77.6 percent); however, approximately one quarter (22.4 percent) of them entered Turner Cut. Route-specific survival probability for tagged steelhead using the Turner Cut route was 27.0 percent. The survival probability for tagged steelhead using the Mainstem route was 56.7 percent (Delaney et al. 2014). Travel times for tagged steelhead also differed between these two routes with steelhead using the mainstem route reaching Chipps Island significantly sooner than those that used the Turner Cut route. Travel time was not significantly affected by the limited OMR flow treatments examined in their study. While not significant, there was some evidence that fish movement toward each export facility could be influenced by relative flow entering the export facility (Delaney et al. 2014).

Water from the San Joaquin River mainly moves downstream through the Head of Old River and through the channels of Old and Middle rivers and Grant Line and Fabian-Bell canals toward the south Delta intake facilities. Conversely, when water to the north of the diversion points for the two facilities moves southward (upstream), the net flow is negative (toward) the pumps. When the temporary barriers are installed from April through November, internal reverse circulation is created within the channels isolated by the barriers from other portions of the south Delta. These conditions are most pronounced during late spring through fall when San Joaquin River inflows are low and water diversion rates are typically high. Drier hydrologic years also reduce the frequency of net downstream flows in the south Delta and mainstem San Joaquin River.

A portion of fish that enter the CVP Jones Pumping Plant approach channel and the SWP Clifton Court Forebay are salvaged at screening and fish salvage facilities, transported downstream by trucks, and released. NMFS (2009a) estimates that the direct loss of fish from the screening and salvage process is in the range of 65 to 83.5 percent for fish from the point they enter Clifton Court Forebay or encounter the trash racks at the CVP facilities. Additionally, mark-recapture experiments indicate that most fish are probably subject to predation prior to reaching the fish salvage facilities (e.g., in Clifton Court Forebay) (Gingras 1997, Clark et al. 2009, Castillo et al. 2012). Aquatic organisms (e.g., phytoplankton and zooplankton) that serve as food for fish also are entrained and removed from the Delta (Jassby et al. 2002, Kimmerer et al. 2008, Brown et al. 1996). Fish entrainment and salvage are particular concerns during dry years when the distributions of young Striped Bass, Delta Smelt, Longfin Smelt, and other migratory fish species shift closer to the project facilities (Stevens et al. 1985, Sommer et al. 1997).

Salvage estimates reflect the number of fish entrained by project exports, but these numbers alone do not account for other sources of mortality related to the export facilities. These numbers do not include prescreen losses that occur in the waterways leading to the diversion facilities, which may in some cases reduce the number of salvageable fish (Gingras 1997, Clark et al. 2009, Castillo et al. 2012). For Delta Smelt, prescreen losses appear to be where most mortality occurs (Castillo et al. 2012). In addition, actual salvage numbers do not include the entrainment of fish larvae, which cannot be collected by the fish screens. The number of fish salvaged also does not include losses of fish that pass through the louvers intended to guide fish into the fish collection facilities or the losses during collection, handling, transport, and release back into the Delta.

The life stage of the fish at which entrainment occurs may be important for population dynamics (IRP 2011). For example, winter entrainment of Delta Smelt, Longfin Smelt, and Threadfin Shad may correspond to migration and spawning of adult fish, and spring and summer exports may overlap with development of larvae and juveniles. The loss of prespawning adults and all their potential progeny may have greater consequences than entrainment of the same number of larvae or juvenile fish. Entrainment risk for fish tends to increase with increased reverse flows in Old and Middle rivers (Kimmerer 2008, Grimaldo et al. 2009).

Research conducted during 2010 and 2011 showed that upriver movements of adult Delta Smelt are achieved through a form of tidal rectification or active tidal transport by using lateral movement to shallow edges of channels on ebb tides to maintain their position (IRP 2010, 2011). Turbidity gradients could be involved in the lateral positioning of Delta Smelt within the channels, but large-scale turbidity pulses through the system may not be necessary to trigger upriver migrations of Delta Smelt if they are already occupying sufficiently turbid water (IRP 2011). The new understanding of potential tidal and turbidity effects on Delta Smelt behavior may have important implications for the Delta Smelt monitoring programs that are the basis for biological triggers for RPA Actions 1 and 2 by understanding the catch efficiency of mid-water trawl data in relation to the lateral positioning of Delta Smelt within channels.

There are more than 2,200 diversions in the Delta (Herren and Kawasaki 2001). These irrigation diversion pipes are shore-based, typically small (30 to 60 centimeter pipe diameter), and operated via pumps or gravity flow, and most lack fish screens. These diversions increase total fish entrainment and losses and alter local fish movement patterns (Kimmerer and Nobriga 2008). Delta Smelt have been found in samples of Delta irrigation diversions, as well as larger wetland management diversions downstream. However, Nobriga et al. (2004) found that the low and inconsistent entrainment of Delta Smelt measured in the study reflected habitat use by Delta Smelt and relatively small hydrodynamic influence of the diversion.

9.3.4.12.7 Disease

Preliminary results of several histopathological studies have found evidence of significant disease in Delta fish species (Reclamation 2008a). For example, massive intestinal infections with an unidentified myxosporean were found in yellowfin goby collected from Suisun Marsh (Baxa et al. 2013). Studies by Bennett (2005) and Bennett et al. (2008) show that exposure to toxic chemicals may cause liver abnormalities and cancerous cells in Delta Smelt, and stressful summer conditions, warm water, and lack of food may result in liver glycogen depletion and liver damage. Studies of Sacramento Splittail suggest that liver abnormalities in this species are more linked to health and nutritional status than to pollutant exposure (Greenfield et al. 2008).

Additionally, preliminary evidence suggests that contaminants and disease may impair Striped Bass. Studies by Lehman et al. (2010) suggest that the liver tissue and health of Striped Bass and Mississippi Silverside were adversely affected by tumors, particularly at sampling stations where concentrations of tumor-promoting microcystins were elevated. Exposure of Sacramento Splittail and Threadfin Shad to microcystins in experimental diets resulted in severe liver damage; shad also exhibited ovarian necrosis, indicating impairment of health and reproductive potential (Acuna et al. 2012).

In contrast, histopathological and viral evaluation of juvenile Longfin Smelt and Threadfin Shad collected in 2006 indicated no histological abnormalities and no evidence of viral infections or high parasite loads (Foott et al. 2006). Parasites were noted in Threadfin Shad gills at a high frequency, but the infections were not considered severe. Thus, both Longfin Smelt and Threadfin Shad were considered healthy in 2006 (a high-flow year). Adult Delta Smelt collected from the Delta during winter 2005 also were considered healthy, showing little histopathological evidence for starvation or disease (Reclamation 2008a). However, there was some evidence of low frequency endocrine disruption. In 2005, 9 of 144 (6 percent) of adult Delta Smelt males were intersex, having immature oocytes in their testes (Reclamation 2008a).

9.3.4.12.8 Nonnative Invasive Species

Nonnative invasive species influence the Delta ecosystem by increasing competition and predation on native species, reducing habitat quality (as result of invasive aquatic macrophyte growth), and reducing food supplies by altering the aquatic food web. Not all nonnative species are considered invasive[2]. Some introduced species have minimal ability to spread or increase in abundance. Others have commercial or recreational value (e.g., Striped Bass, American Shad, and Largemouth Bass).

Many nonnative fishes have been introduced into the Delta for sport fishing (game fish such as Striped Bass, Largemouth Bass, Smallmouth Bass, Bluegill, and other sunfish), as forage for game fish (Threadfin Shad, Golden Shiner, and Fathead Minnow), for vector control (Inland Silverside, Western Mosquitofish), for human food use (Common Carp, Brown Bullhead, and White Catfish), and from accidental releases (Yellowfin Goby, Shimofuri Goby, and Shokihaze Goby) (Moyle 2002). Introduced fish may compete with native fish for resources and, in some cases, prey on native species.

Because of invasive species and other environmental stressors, native fishes have declined in abundance throughout the region during the period of monitoring (Matern et al. 2002, Brown and Michniuk 2007, Sommer et al. 2007a, Mount et al. 2012). Habitat degradation, changes in hydrology and water quality, and stabilization of natural environmental variability are all factors that generally favor nonnative, invasive species (Mount et al. 2012, Moyle et al. 2012).

9.3.4.12.9 Predation

Predation is an important factor that influences the behavior, distribution, and abundance of prey species in aquatic communities to varying degrees. Predation can have differing effects on a population of fish depending on the size or age selectivity, mode of capture, mortality rates, and other factors. Predation is a part of every food web, and native Delta fishes were part of the historical Delta food web. Because of the magnitude of change in the Delta from historical times and

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[2] DFG (2008) defines “invasive species” as “species that establish and reproduce rapidly outside of their native range and may threaten the diversity or abundance of native species through competition for resources, predation, parasitism, hybridization with native populations, introduction of pathogens, or physical or chemical alteration of the invaded habitat.”

the introduction of nonnative predators, it is logical to conclude that predation may have increased in importance as a mortality factor for Delta fishes, with some observers suggesting that it is likely the primary source of mortality for juvenile salmonids in the Delta (Vogel 2011). Predation occurs by fish, birds, and mammals, including sea lions. The alternatives considered in this EIS are not anticipated to modify predatory actions of birds and mammals on the focal species. Therefore, the predation discussion is focused on fish predators.

A panel of experts recently convened to review data on predation in the Delta and draw preliminary conclusions on the effects of predation on salmonids. The panel acknowledged that the system supports large populations of fish predators that consume juvenile salmonids (Grossman et al. 2013). However, the panel concluded that because of extensive flow modification, altered habitat conditions, native and nonnative fish and avian predators, temperature and dissolved oxygen limitations, and the overall reduction in salmon population size, it was unclear what proportion of the juvenile salmonid mortality could be attributed to predation. The panel further indicated that predation, while the proximate cause of mortality, may be influenced by a combination of other stressors that make fish more vulnerable to predation.

Striped Bass, White Catfish, Largemouth Bass and other centrarchids, and silversides are among the introduced, nonnative species that are notable predators of smaller-bodied fish species and juveniles of larger species in the Delta. Along with Largemouth Bass, Striped Bass are believed to be major predators on larger-bodied fish in the Delta. In open-water habitats, Striped Bass are most likely the primary predator of juvenile and adult Delta Smelt (DWR et al. 2013) and can be an important open-water predator on juvenile salmonids (Johnston and Kumagai 2012). Native Sacramento Pikeminnow may also prey on juvenile salmonids and other fishes. Limited sampling of smaller pikeminnows did not find evidence of salmonids in the foregut of Sacramento Pikeminnow (Nobriga and Feyrer 2007), but this does not mean that Sacramento Pikeminnow do not prey on salmonids in the Delta.

Largemouth Bass abundance has increased in the Delta over the past few decades (Brown and Michniuk 2007). Although Largemouth Bass are not pelagic, their presence at the boundary between the littoral and pelagic zones makes it probable that they opportunistically consume pelagic fishes. The increase in salvage of Largemouth Bass occurred during the time period when Brazilian waterweed was expanding its range in the Delta (Brown and Michniuk 2007). The beds of Brazilian waterweed provide good habitat for Largemouth Bass and other species of centrarchids. Largemouth Bass have a much more limited distribution in the estuary than Striped Bass, but a higher per-capita impact on small fishes (Nobriga and Feyrer 2007). Increases in Largemouth Bass may have had a particularly important effect on Threadfin Shad and Striped Bass, whose earlier life stages occur in littoral habitat (Grimaldo et al. 2004, Nobriga and Feyrer 2007).

Invasive Mississippi silversides are another potentially important predator of larval and pelagic fishes in the Delta. This introduced species was not believed to be an important predator on Delta Smelt, but recent studies using DNA techniques detected the presence of Delta Smelt in the guts of 41 percent of Mississippi silversides sampled in mid-channel trawls (Baerwald et al. 2012). This finding may suggest that predation impacts could be significant, given the increasing numbers of Mississippi silversides in the Delta.

Predation of fish in the Delta is known to occur in specific areas, for example at channel junctions and areas that constrict flow or confuse migrating fish and provide cover for predatory fish (Vogel 2011). Sabal (2014) found similar results at Woodbridge Dam on the Mokelumne River where the dam was associated with increased Striped Bass per capita salmon consumption and attracted larger numbers of Striped Bass, decreasing migrating juvenile salmon survival by 10 to 29 percent. DFG (1992) identified subadult Striped Bass as the major predatory fish in Clifton Court Forebay. In 1993, for example, Striped Bass made up 96 percent of the predators removed (Vogel 2011). Cavallo et al. (2012) studied tagged salmon smolts to test the effects of predator removal on outmigrating juvenile Chinook Salmon in the south Delta. Their results suggested that predator abundance and migration rates strongly influenced survival of salmon smolts. Exposure time to predators has been found to be important for influencing survival of outmigrating salmon in other studies in the Delta (Perry et al. 2012).

9.3.4.12.10 Aquatic Macrophytes

Aquatic macrophytes are an important component of the biotic community of Delta wetlands and can provide habitat for aquatic species, serve as food, produce detritus, and influence water quality through nutrient cycling and dissolved oxygen fluctuations. Whipple et al. (2012) described likely historical conditions in the Delta, which have been modified extensively, with major impacts on the aquatic macrophyte community composition and distribution. The primary change has been a shift from a high percentage of emergent aquatic macrophyte wetlands to open water and hardened channels.

The introduction of two nonnative invasive aquatic plants, water hyacinth and Brazilian waterweed, has reduced habitat quantity and value for many native fishes. Water hyacinth forms floating mats that greatly reduce light penetration into the water column, which can significantly reduce primary productivity and available food for fish in the underlying water column. Brazilian waterweed grows along the margins of channels in dense stands that prohibit access by native juvenile fish to shallow water habitat. Additionally, the thick cover of these two invasive plants provides excellent habitat for nonnative ambush predators, such as bass, which prey on native fish species. Studies indicate low abundance of native fish, such as Delta Smelt, Chinook Salmon, and Sacramento Splittail, in areas of the Delta where submerged aquatic vegetation infestations are thick (Grimaldo et al. 2004, 2012; Nobriga et al. 2005).

Invasive aquatic macrophytes are still equilibrating within the Delta and resulting habitat changes are ongoing, with negative impacts on habitats and food webs of native fish species (Toft et al. 2003, Grimaldo et al. 2009). Concerns about invasive aquatic macrophytes are centered on their ability to form large, dense growth that can clog waterways, block fish passage, increase water clarity, provide cover for predatory fish, and cause high biological oxygen demand.

9.3.4.13 Yolo Bypass

The Yolo Bypass conveys flood flows from the Sacramento Valley, including the Sacramento River, Feather River, American River, Sutter Bypass, and west side streams

The Yolo Bypass provides habitat for a wide variety of fish and aquatic species, including temporary migration corridors and juvenile rearing habitat for anadromous salmonids and other native and anadromous fishes. Species captured as adults and subsequently collected as YOY suggest that the Yolo Bypass provides spawning habitat for these species, including splittail, American Shad, Striped Bass, Threadfin Shad, Largemouth Bass and carp (Harrell and Sommer 2003, Sommer et al. 2014). The Yolo Bypass lacks suitable gravel substrate that would support salmon spawning.

9.3.4.13.1 Aquatic Habitat

Aquatic habitats in the Yolo Basin include stream and slough channels for fish migration, and when flooded, seasonal spawning habitat and productive rearing habitat (Sommer et al. 2001a; CALFED 2000a, 2000b). During years when the Yolo Bypass is flooded, it serves as an important migratory route for juvenile Chinook Salmon and other native migratory and anadromous fishes moving downstream. During these times, it provides juvenile anadromous salmonids an alternative migration corridor to the lower Sacramento River (Sommer et al. 2003) and, sometimes, better rearing conditions than the adjacent Sacramento River channel (Sommer et al. 2001a, 2005). When the floodplain is activated, juvenile salmon can rear for weeks to months in the Yolo Bypass floodplain before migrating to the estuary (Sommer et al. 2001a). Research on the Yolo Bypass has found that juvenile salmon grow substantially faster in the Yolo Bypass floodplain than in the adjacent Sacramento River, primarily because of greater availability of invertebrate prey in the floodplain (Sommer et al. 2001a, 2005). When not flooded, the lower Yolo Bypass provides tidal habitat for young fish that enter from the lower Sacramento River via Cache Slough Complex (McLain and Castillo; DWR, unpublished data).

Sommer et al. (1997) demonstrated that the Yolo Bypass is one of the single most important habitats for Sacramento Splittail. Because the Yolo Bypass is dry during summer and fall, nonnative species (e.g., predatory fishes) generally are not present year-round except in perennial water sources (Sommer et al. 2003). In addition to providing important fish habitat, seasonal inundation of the Yolo Bypass supplies phytoplankton and detritus that may benefit aquatic organisms downstream in the brackish portion of the San Francisco Estuary (Sommer et al. 2004, Lehman et al. 2008a).

9.3.4.13.2 Fish Passage

The Fremont Weir is a major impediment to fish passage and a source of migratory delay and loss of adult Chinook Salmon, steelhead, and sturgeon (NMFS 2009a, Sommer et al. 2014). The Fremont Weir creates a migration barrier for a variety of species, although fish with strong jumping capabilities such as salmonids may be able to pass the weir at higher flows. Although there is a fish ladder maintained by CDFW at the center of the weir, the ladder is small, outdated, and inefficient. Additionally, there are no facilities at the weir to pass upstream migrants at lower flows. Some adult winter-run, spring-run, and fall-run Chinook Salmon and White Sturgeon migrate into Yolo Bypass when there is no flow into the floodplain via the Fremont Weir. Therefore, these fish are often unable to reach upstream spawning habitat in the Sacramento River and its tributaries (Harrell and Sommer 2003, Sommer et al. 2014). Other structures in the Yolo Bypass, such as the Toe Drain, Lisbon Weir, and irrigation dams in the northern end of the Tule Canal, also may impede upstream passage of adult anadromous fish (NMFS 2009a).

Fish are also attracted into the bypass during periods when water is not flowing over the Fremont Weir. Fyke trap monitoring by DWR has shown that adult salmon and steelhead migrate up the Toe Drain in autumn and winter regardless of whether the Fremont Weir spills (Harrell and Sommer 2003, Sommer et al. 2014). The Toe Drain does not extend to the Fremont Weir because the channel is blocked by roads or other higher ground at several locations. Sturgeon and salmonids attracted by high flows into the basin become concentrated behind the Fremont Weir, where they are subject to heavy legal and illegal fishing pressure.

Stranding of juvenile salmonids and sturgeon has been reported in the Yolo Bypass in scoured areas behind the weir and in other areas as floodwaters recede (NMFS 2009a, Sommer et al. 2005). However, Sommer et al. (2005) found most juvenile salmon outmigrated off the floodplain as it drained.

9.3.4.14 Suisun Marsh

Suisun Bay and Marsh are ecologically linked with the central Delta, although with different tidal and salinity conditions than found upstream. Suisun Bay and Marsh are the largest expanse of remaining tidal marsh habitat within the greater San Francisco Bay-Delta ecosystem and include Honker, Suisun, and Grizzly bays; Montezuma and Suisun sloughs; and numerous other smaller channels and sloughs.

9.3.4.14.1 Aquatic Habitat

Suisun Marsh is a brackish-water marsh bordering the northern edge of Suisun Bay. Most of its marsh area consists of diked wetlands managed for waterfowl, with the rest of the acreage consisting of tidally influenced sloughs (Suisun Ecological Workgroup 2001). The central latitudinal location of Suisun Marsh within the San Francisco Estuary makes it an important rearing area for euryhaline freshwater, estuarine, and marine fishes. Many fish species that migrate or use Delta habitats also are found in the waters of Suisun Bay.

Tides reach Suisun Bay and Marsh through the Carquinez Strait, and most freshwater flows enter at the southeast border of Suisun Marsh at the confluence of the Sacramento and San Joaquin rivers. The mixing of freshwater outflows from the Central Valley with saline tidal water in Suisun Bay and Suisun Marsh results in brackish water with strong salinity gradients, complex patterns of flow interactions, and generally the highest biomass productivity in the entire estuary (Siegel et al. 2010).

Although the fish assemblages in Suisun Bay and Marsh can differ substantially from the fish assemblages in the Delta, all the species that use the Delta also use Suisun Bay and Marsh.

Flow, turbidity, and salinity are important factors influencing the location and abundance of zooplankton and small prey organisms used by Delta species (Kimmerer et al. 1998). The location where net current flowing inland along the bottom reverses direction and sinking particles are trapped in suspension is associated with higher turbidity known as the estuarine turbidity maximum. Burau et al. (2000) reports that the estuarine turbidity maximum occurs near the Benicia Bridge and in Suisun Bay near Garnet Point on Ryer Island. Zooplanktonic organisms maintain position in this region of historically high productivity in the estuary through vertical movements (Kimmerer et al. 1998).

Salinity in the Suisun Bay and Marsh system is a major water quality characteristic that strongly influences physical and ecological processes. Fish species native to Suisun Marsh require low salinities during the spawning and rearing periods (Suisun Ecological Workgroup 2001; Kimmerer 2004; Feyrer et al. 2007, 2010; Nobriga et al. 2008). The Suisun Bay and Marsh usually contain both the maximum estuarine salinity gradient and the low salinity zone. The overall estuarine salinity gradient trends from west (higher) to east (lower) in Suisun Bay and Marsh. The location of the low salinity zone gradient and X2 can be influenced by outflow. Suisun Marsh also exhibits a persistent north-south salinity gradient. Despite low and seasonal flows, the surrounding watersheds have a significant water freshening effect because of the long residence times of freshwater discharges from the upper sloughs and wastewater effluent.

The Suisun Bay and Marsh system contains a wide variety of habitats such as marsh plains, tidal creeks, sloughs, channels, cuts, mudflats, and bays. These features and the complex hydrodynamics and water quality of the system have historically fostered significant biodiversity within Suisun tidal aquatic habitats, but, like the Delta, these habitats also have been significantly altered and degraded by human activities over the decades.

Categories of tidal aquatic habitat were identified as part of the Suisun Marsh Plan development process and were defined using physical boundaries; habitats include bays, major sloughs, minor sloughs, and the intertidal mudflats in those areas (Engle et al. 2010). These tidal habitats total approximately 26,000 acres, with the various embayments totaling about 22,350 acres. Tidal slough habitat is composed of major and minor sloughs, with major sloughs of Suisun Marsh having a combined acreage of about 2,200 acres consisting of both shallow and deep channels. Minor sloughs are made up of shallow channel habitat and have a combined acreage of about 1,100 acres. Habitats in Suisun Marsh bays and sloughs support a diverse assemblage of aquatic species that typically use open-water tidal areas for breeding, foraging, rearing, or migrating.

9.3.4.14.2 Fish Entrainment

Several facilities have been constructed by DWR and Reclamation to provide lower-salinity water to managed wetlands in the Suisun Marsh, including the Roaring River Distribution System, Morrow Island Distribution System, and Goodyear Slough Outfall. Other facilities constructed under the Suisun Marsh Preservation Agreement that could entrain fish include the Lower Joice Island and Cygnus Drain diversions.

The intake to the Roaring River Distribution System is screened to prevent entrainment of fish larger than approximately 25 mm (approximately 1 inch). DWR monitored fish entrainment from September 2004 to June 2006 at the Morrow Island Distribution System to evaluate entrainment losses at the facility. Monitoring took place over several months under various operational configurations and focused on Delta Smelt and salmonids. Over 20 species were identified during the sampling, but only 2 fall-run-sized Chinook Salmon (at the South Intake in 2006) and no Delta Smelt from entrained water were caught (Reclamation 2008a). The Goodyear Slough Outfall system is open for free fish movement except near the outfall when flap gates are closed during flood tides (Reclamation 2008a). Conical fish screen have been installed on the Lower Joice Island diversion on Montezuma Slough.

9.3.4.15 San Joaquin River from Confluence of the Stanislaus River to the Delta

Since the construction of Friant Dam, significant changes in physical (fluvial geomorphic) processes and substantial reductions in streamflows in the San Joaquin River have occurred, resulting in large-scale alterations to the river channel and associated aquatic, riparian, and floodplain habitats. Throughout the area, there are physical barriers, reaches with poor water quality or no surface flow, and false migration pathways that have reduced habitat connectivity for anadromous and resident native fishes (Reclamation and DWR 2011). As a result, there has been a general decline in both the abundance and distribution of native fishes, with several species extirpated from the system (Moyle 2002).

Moyle (2002) reported that of the 21 native fish species historically present in the San Joaquin River, at least 8 are now uncommon, rare, or extinct. The deep-bodied fish assemblage (e.g., Sacramento Splittail, Sacramento Blackfish) has been replaced by nonnative species like carp and catfish.

The San Joaquin River from the Stanislaus River to the Delta is dominated by nonnative species such as Largemouth Bass, Inland Silverside, carp, and several species of sunfish and catfish (Moyle 2002). Anadromous species include fall-run Chinook Salmon, steelhead, Striped Bass, American Shad, White Sturgeon, and several species of lamprey (Reclamation et al. 2003). The fall-run Chinook

Salmon population is supported in part by hatchery stock in the Merced River. Spawning by anadromous salmonids in the San Joaquin River Basin occurs only in the tributaries to the San Joaquin River, including the Merced, Tuolumne, and Stanislaus rivers (Brown and Moyle 1993). Spring-run Chinook Salmon no longer exist in the San Joaquin River, but are targeted for restoration in this system under Reclamation's San Joaquin River Restoration Program. In early 2015, the program experimentally released juvenile spring-run Chinook Salmon into the San Joaquin River near the Merced River. Surviving adults may return to the San Joaquin River as early as spring 2017. Because of the uncertainty of future restoration success and the current lack of natural presence in the San Joaquin River, spring-run Chinook Salmon is not included in the analysis of San Joaquin River fish.

9.3.4.15.1 Fish in the San Joaquin River

The analysis is focused on the following species:

- Fall-run Chinook Salmon
- Steelhead
- White Sturgeon
- Sacramento Splittail
- Pacific Lamprey
- Striped Bass
- American Shad

Fall-run Chinook Salmon

Fall-run Chinook Salmon are present in the San Joaquin River and its major tributaries upstream to and including the Merced River. Spawning and rearing occur in the major tributaries (Merced, Tuolumne, and Stanislaus rivers) downstream of the mainstem dams. Weir counts in the Stanislaus River suggest that adult fall-run Chinook Salmon in the San Joaquin River Basin typically migrate into the upper rivers between late September and mid-November and spawn shortly thereafter (Pyper et al. 2006; Anderson et al. 2007; FISHBIO 2010a, 2011).

The San Joaquin River downstream of the Stanislaus River primarily provides upstream passage for adult fall-run Chinook Salmon and downstream passage for juveniles and smolts as they outmigrate from the tributary spawning and rearing areas to the Delta to the Pacific Ocean. The juvenile fall-run Chinook Salmon outmigration in the San Joaquin River Basin typically occurs during winter and spring, extending primarily from January through May. The outmigration consists primarily of fry in winter and smolts in spring (FISHBIO 2007, 2013). Trawl sampling in the lower San Joaquin River from Mossdale to the Head of Old River (the Mossdale Trawl) captures Chinook Salmon from February into July, with peak catches generally during April and May (Speegle et al. 2013).

Steelhead

Steelhead were historically present in the San Joaquin River, though data on their population levels are lacking (McEwan 2001). The current steelhead population in the San Joaquin River is substantially reduced compared with historical levels, although resident Rainbow Trout occur throughout the major San Joaquin River tributaries. Additionally, small populations of steelhead persist in the lower San Joaquin River and tributaries (e.g., Stanislaus, Tuolumne, and possibly the Merced rivers) (Zimmerman et al. 2009, McEwan 2001). Steelhead/Rainbow Trout of anadromous parentage occur at low numbers in all three major San Joaquin River tributaries. These tributaries have a higher percentage of resident Rainbow Trout compared to the Sacramento River and its tributaries (Zimmerman et al. 2009).

Presence of steelhead smolts from the San Joaquin River Basin is estimated annually by CDFW based on the Mossdale Trawl (SJRGA 2011). The sampling trawls capture steelhead smolts, although usually in small numbers. One steelhead smolt was captured and returned to the river during the 2009 sampling period (SJRGA 2010), and three steelhead were captured and returned in both 2010 and 2011 (Speegle et al. 2013).

Sacramento Splittail

Historically, Sacramento Splittail were widespread in the San Joaquin River and found upstream to Tulare and Buena Vista lakes, where they were harvested by native peoples (Moyle et al. 2004). Today, Sacramento Splittail likely ascend the San Joaquin River to Salt Slough during wet years (Baxter 1999). During dry years, Sacramento Splittail are uncommon in the San Joaquin River downstream of the Tuolumne River (Moyle et al. 2004). Most spawning takes place in the flood bypasses, along the lower reaches of the Sacramento and San Joaquin rivers and major tributaries, and lower Cosumnes River and similar areas in the western Delta.

Most juveniles apparently move downstream into the Delta from April to August (Meng and Moyle 1995). Factors influencing the Sacramento Splittail population are unclear, but the population is largely influenced by extent and period of inundation of floodplain spawning habitats, with abundance spiking following wet years and declining after dry years (Moyle et al. 2004). Other factors that may influence the San Joaquin River portion of the population include flood control, entrainment by diversion, recreational fishing, pollutants, and nonnative species (Moyle et al. 2004).

Pacific Lamprey

The Pacific Lamprey is a widely distributed anadromous species found in accessible reaches of the San Joaquin River and many of its tributaries.

Data from mid-water trawls in the lower San Joaquin River near Mossdale indicate that adults likely migrate into the San Joaquin River in spring and early summer (Hanni et al. 2006). In other large river systems, the initial adult migration from the ocean generally stops in summer, and Pacific Lampreys hold until the following winter or spring before undergoing a secondary migration to spawning grounds (Robinson and Bayer 2005, Clemens et al. 2012). Midwater trawl surveys in the San Joaquin River suggest that peak ammocoete outmigration occurs in January and February (Hanni et al. 2006).

Little information is available on factors influencing Pacific Lamprey in the San Joaquin River, but they are likely affected by many of the same factors as salmon and steelhead because of parallels in their life cycles. Lack of access to historical spawning habitats because of the mainstem dams and other migration barriers, modification of spawning and rearing habitats, altered hydrology, entrainment by water diversions, and predation by nonnative invasive species such as Striped Bass all likely influence Pacific Lamprey in the San Joaquin River and tributaries.

Striped Bass

Striped Bass are regularly found in San Joaquin River tributaries, including in lower mainstem deep pools of the Stanislaus and Tuolumne rivers (e.g., Anderson et al. 2007). Ainsley et al. (2013) reported that Striped Bass were collected at two locations between the Head of the Old River and the mouth of the Stanislaus River on the mainstem San Joaquin River in May.

American Shad

Little is known about American Shad populations inhabiting the San Joaquin River. American Shad may spawn in the San Joaquin River system, but their abundance is unknown. Sport fishing for American Shad occurs seasonally in the San Joaquin River.

Sturgeon

Little is known about White Sturgeon populations inhabiting the San Joaquin River. Spawning-stage adults generally move into the lower reaches of rivers during winter prior to spawning, then migrate upstream to spawn in response to higher flows (Schaffter 1997, McCabe and Tracy 1994). Based on tag returns from White Sturgeon tagged in the Sacramento-San Joaquin Estuary and recovered by anglers, Kohlhorst et al. (1991) estimated that over 10 times as many White Sturgeon spawn in the Sacramento River as in the San Joaquin River.

CDFW fisheries catch information for the San Joaquin River obtained from fishery report cards (DFG 2008b, 2009b, 2010, 2011, 2012b; CDFW 2013, 2014) documented that anglers upstream of Highway 140 caught between 8 and 25 mature White Sturgeon annually between 2007 and 2013. Below Highway 140 downstream to Stockton, anglers caught between 2 and 35 mature White Sturgeon annually over the same time period; most of the White Sturgeon caught were released.

White Sturgeon spawning in the San Joaquin River was documented for the first time in 2011 and confirmed in 2012. Viable White Sturgeon eggs were collected in 2011 at one sampling location downstream of Laird Park (Gruber et al. 2012) and in 2012 at four sampling locations generally between Laird Park and the Stanislaus River confluence (Jackson and Van Eenennaam 2013). Although the majority of sturgeon likely spawn in the Sacramento River, the results of these surveys confirm that White Sturgeon do spawn in the San Joaquin River in both wet- and dry-year conditions and may be an important source of production for the White Sturgeon population in the Sacramento-San Joaquin river system.

Green Sturgeon are also present in the San Joaquin River, but at considerably lower numbers than White Sturgeon. Between 2007 and 2012, anglers reported catching six Green Sturgeon in the San Joaquin River (Jackson and Van Eenennaam 2013). Although the reported presence of Green Sturgeon in the San Joaquin River coincides with the spawning migration period of Green Sturgeon within the Sacramento River, no evidence of spawning has been detected (Jackson and Van Eenennaam 2013).

9.3.4.15.2 Aquatic Habitat

Aquatic habitat conditions vary spatially and temporally throughout the lower San Joaquin River because of differences in habitat availability and connectivity, water quantity and quality (including water temperature), and channel morphology.

Downstream of the Stanislaus River confluence, the San Joaquin River is more sinuous than upstream reaches and contains oxbows, side channels, and remnant channels. It conveys the combined flows of the major tributaries, including the Merced, Tuolumne, Stanislaus, and Calaveras rivers. Flood control levees closely border much of the river but are set back in places, creating some off-channel aquatic habitat areas when inundated (Reclamation and DWR 2011). The channel gradient in this portion of the San Joaquin River is low, and the lack of gravel or coarser substrate precludes spawning by salmonids.

9.3.4.15.3 Fish Passage

In the reach of the river downstream of the confluence of the Stanislaus River, fish encounter passage challenges associated with water diversions, and adult salmon migrating upstream from the Delta also may encounter prohibitively high stream temperatures that delay migration until temperatures decline (McBain and Trush 2002). Installation of seasonal barriers in the Delta also can impair fish passage.

9.3.4.15.4 Hatcheries

No hatcheries in the San Joaquin River Basin are affected by CVP or SWP operations. The Merced River Hatchery, located on the Merced River, is operated by CDFW to supplement the fall-run Chinook Salmon population. It is not included in the CVP or SWP service areas. As part of the San Joaquin River Restoration Program, CDFW has begun operation of a conservation hatchery downstream of Friant Dam to produce spring-run Chinook Salmon (Reclamation and DWR 2010).

9.3.4.15.5 Predation

Recent studies of predation in the San Joaquin River are limited to the major tributaries, where largemouth and Smallmouth Bass have been identified as the most important predators of juvenile Chinook Salmon (McBain and Trush and

Stillwater Sciences 2006). Striped Bass also have been identified as salmon predators, though recent evidence for the San Joaquin River is lacking.

9.3.4.16 New Melones Reservoir, Tulloch Reservoir, and Goodwin Dam

The north, middle, and south forks of the Stanislaus River converge upstream of the CVP New Melones Reservoir. Water from New Melones Reservoir flows into Tulloch Reservoir (Reclamation 2010b). Downstream of Tulloch Reservoir, the Stanislaus River flows through the reservoir formed by Goodwin Dam and then approximately 40 miles to the confluence with the San Joaquin River.

New Melones Reservoir is located approximately 60 miles upstream from the confluence of the Stanislaus and San Joaquin rivers and is operated by Reclamation. New Melones Reservoir is an artificial environment and does not support a naturally evolved aquatic community. Most of the species in the reservoir were introduced, although a few native species may still be present. From a fisheries perspective, recreational fishing is the most important use of New Melones Reservoir. Fish species in New Melones Reservoir include Rainbow Trout, Brown Trout, Largemouth Bass, sunfishes such as Black Crappie and Bluegill, and three species of catfish (Reclamation 2010b). Rainbow Trout, Brown Trout, and large Channel Catfish are generally restricted to colder, deeper water during summer, when New Melones Reservoir has two distinct thermal layers of water, although large Brown Trout and Channel Catfish are found in shallow water near steep banks at night when they ascend to feed.

Tulloch Reservoir is operated as an afterbay for the New Melones Reservoir and is subject to fluctuating water levels that occur on a daily and seasonal basis. Tulloch Reservoir stratifies weakly during summer and contains a reserve of relatively cold, well-oxygenated water that is released downstream. Tulloch Reservoir supports both warm and cold freshwater habitat. Goodwin Power (2013) reported that DFG captured 15 species in Tulloch Reservoir from 1969 through 1998. Five dominant species made up almost 80 percent of the catch; White Catfish (31 percent of the total), Bluegill (20 percent), Sacramento Sucker (11 percent), Smallmouth Bass (10 percent), and Black Crappie (7 percent). Of these, only the Sacramento Sucker is native. Other native species in the catch were Sacramento Hitch, Hardhead, Sacramento Pikeminnow, and Rainbow Trout (now stocked). Other nonnative fish found in Tulloch reservoir include Largemouth Bass and Threadfin Shad (DFG 2002b).

Little information exists regarding aquatic resources in the reservoir formed by Goodwin Dam. It is assumed that fish assemblies are similar to those described for Tulloch Reservoir.

9.3.4.17 Stanislaus River from Goodwin Dam to the San Joaquin River

9.3.4.17.1 Fish in the Stanislaus River

Steelhead and fall-run Chinook Salmon currently occur in the lower Stanislaus River. Historically, spring-run Chinook Salmon were believed to be the primary salmon run in the Stanislaus River. Native spring-run Chinook salmon have been extirpated from all tributaries in the San Joaquin River Basin, which represents a large portion of their historic range and abundance (NMFS 2014b). Other anadromous fish species that occur in the lower Stanislaus River include Striped Bass, American Shad, and an unidentified species of lamprey (SRFG 2003). The analysis is focused on the following species:

- Fall-run Chinook Salmon
- Steelhead
- Pacific Lamprey
- Striped Bass
- American Shad

Fall-run Chinook Salmon

Data collected by private fishery consultants, nonprofit organizations, and DFG demonstrate the majority of fall-run Chinook Salmon adults migrate upstream from late September through December with peak migration from late October through early November. Most Chinook Salmon spawning occurs between Riverbank (River Mile 33) and Goodwin Dam (River Mile 58.4) (Reclamation 2012b). Based on redd surveys conducted by FISHBIO, peak spawning typically occurs in November with roughly 7 percent of spawning occurring prior to November 1, and 2 percent prior to October 15. The few redds created during late September and early October are typically in the reach just below Goodwin Dam. By late October, the amount of spawning in downstream locations increases as water temperatures decrease, and the median redd location is typically around Knights Ferry (SWRCB 2015).

In 2010, over 20 percent of the fall-run Chinook Salmon observed passing the Stanislaus River weir had adipose fin clips, indicating the presence of a coded-wire-tag (CWT) in their snout. Since there is no hatchery on the Stanislaus River and no hatchery releases have been conducted into this tributary since 2006, it is apparent that straying from other rivers is occurring (FISHBIO 2010b).

Rotary screw trap data indicate that about 99 percent of salmon juveniles migrate out of the Stanislaus River from January through May (SRFG 2004). Fry migration generally occurs from January through March, followed by smolt migration from April through May (Reclamation 2012). Watry et al. (2012) found that in both 2010 and 1011, peak passage during the pre-smolt period generally corresponded with flow pulses. Zeug et al. (2014) examined 14 years of rotary screw trap data on the lower Stanislaus River and found a strong positive response in survival, the proportion of pre-smolt migrants and the size of smolts when cumulative flow and flow variance were greater and concluded that the data suggested that periods of high discharge in combination with high discharge variance are important for successful emigration as well as migrant size and the maintenance of diverse migration strategies.

Mesick (2001) surmised that when water exports are high relative to San Joaquin River flows, little, if any, San Joaquin River water reaches San Francisco Bay where it may be needed to help attract the salmon back to the Stanislaus River. During mid-October from 1987 through 1989, when export rates exceeded

400 percent of Vernalis flows, Mesick (2001) found that straying rates ranged between 11 and 17 percent. In contrast, straying rates were estimated to be less than 3 percent when Delta export rates were less than about 300 percent of San Joaquin River flow at Vernalis during mid-October.

One of the limiting factors appears to be the high rates of mortality for juveniles migrating through dredged channels in the Stanislaus River and Delta, particularly the Stockton Deep Water Ship Channel (Newcomb and Pierce 2010). Pickard et al. (1982) reported that the survival of juvenile fish in the deep-water ship channel is highest during flood flows or when a barrier is placed at the head of the Old River that more than doubles the flow in the ship channel. The Stanislaus River Fish Group (SRFG) (2004) noted that escapement is also directly correlated with springtime flows when each brood migrates downstream as smolts. However, the cause of the mortality in the ship channel has not been studied. It is possible that mortality results from the combined effects of warm water temperatures, low dissolved oxygen concentrations, ammonia toxicity, and predation.

As discussed earlier, dredging for gravel and gold, regulated flows, and the diking of floodplains for agriculture have substantially limited the availability of spawning and rearing habitat for fall-run Chinook Salmon. Reclamation has conducted spawning gravel augmentation to improve spawning and rearing habitats in the reach between Goodwin Dam and Knights Ferry most years since 1999. The dredged areas also contain an abundance of large predatory fish, although the SRFG concluded that there is uncertainty about whether predation is a substantial source of mortality for juvenile salmon.

The SRFG also concluded that water diversions for urban and agricultural use in all three San Joaquin River tributaries, which reduce flows and potentially result in unsuitably warm water temperatures during spring and fall, affect fall-run Chinook Salmon juvenile rearing and adult and juvenile migration in the lower San Joaquin River and Delta.

Steelhead

Steelhead were thought to be extirpated from the San Joaquin River system (NMFS 2009a). However, monitoring has detected small self-sustaining (i.e., non-hatchery origin) populations of steelhead in the Stanislaus River and other streams previously thought to be devoid of steelhead (SRFG 2003, McEwan 2001). There is a catch-and-release steelhead fishery in the lower Stanislaus River between January 1 and October 15. Surveys of *O. mykiss* (resident trout and the anadromous steelhead) abundance and distribution conducted annually since 2009 have documented a relatively stable population. River-wide abundance estimates from 2009 to 2014 have averaged just over 20,220 (all life stages combined) and have never been estimated to be less than about 14,000 (2009). The highest densities and abundances of *O. mykiss* are consistently found in Goodwin Canyon. Key factors that may contribute to higher-than average abundances in the Stanislaus River (relative to other San Joaquin River tributaries) include high gradient reaches that are typically associated with higher amount of fast-water habitats, particularly in Goodwin Canyon (SWRCB 2015).

Historically, the distribution of steelhead extended into the headwaters of the Stanislaus River (Yoshiyama et al. 1996). Steelhead currently can migrate more than 58 miles up the Stanislaus River to the base of Goodwin Dam. In the Stanislaus River, there is little data regarding the migration patterns of adult steelhead since adults generally migrate during periods when river flows and turbidity are high making fish difficult to observe with standard adult monitoring techniques. Stanislaus River weir data indicate that steelhead migrate upstream, through the South Delta and lower San Joaquin river, between September and March with numbers ranging from 6 to 85[3] between 2008-2011 and 2013 (Reclamation 2014e). High Delta export rates relative to San Joaquin River flows at Vernalis, when adults are migrating through the Delta (presumably December through May), may result in adults straying to the Sacramento River Basin.

It is believed that steelhead spawn primarily between December and March in the Stanislaus River. Although steelhead few steelhead spawning surveys have been conducted in the Stanislaus, spawning *O. mykiss* were documented between Goodwin Dam and Horseshoe Bar in a 2014 spawning survey (Reclamation and DWR 2015). The spawning adults require holding and feeding habitat with cover adjacent to suitable spawning habitat. These habitat features are relatively rare in the lower Stanislaus River because of in-river gravel mining and the scouring of gravel from riffles in Goodwin Canyon.

Juvenile steelhead rear in the Stanislaus River for at least 1 year, and usually 2 years, before migrating to the ocean. As a result, flow, water temperature, and dissolved oxygen concentration in the reach between Goodwin Dam and the Orange Blossom Bridge (their primary rearing habitat) are critical during summer (Reclamation 2012b).

Small numbers of steelhead smolts have been captured in rotary screw traps at Caswell State Park and near Oakdale (FISHBIO 2007; Watry et al. 2007, 2012), and data indicate that steelhead outmigrate primarily from February through May. Rotary screw traps are generally not considered efficient at catching fish as large as steelhead smolts, and the number captured is too small to estimate capture efficiency, so no steelhead smolt outmigration population estimate has been calculated. The capture of these fish in downstream migrant traps and the advanced smolting characteristics exhibited by many of the fish indicate that some steelhead/rainbow juveniles might migrate to the ocean in spring. However, it is not known whether the parents of these fish were anadromous or fluvial (they migrate within fresh water). Resident populations of steelhead/rainbow in large streams are typically fluvial, and migratory juveniles look much like smolts.

Pacific Lamprey

The Pacific Lamprey is a widely distributed anadromous species that inhabits accessible reaches of the Stanislaus River (SRFG 2003). Limited information on Pacific Lamprey status in the Stanislaus River exists, but the species has

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[3] Numbers presented are for all *O. mykiss* passing upstream of the Stanislaus Weir and do not differentiate between adult steelhead and resident rainbow trout that are moving within the river; therefore, actual numbers of steelhead may be lower than those presented.

experienced loss of access to historical habitat and apparent population declines throughout California and the Sacramento and San Joaquin River basins (Moyle et al. 2009). Little information is available on factors influencing Pacific Lamprey populations in the Stanislaus River, but they are likely affected by many of the same factors as salmon and steelhead because of parallels in their life cycles.

Ocean stage adults likely migrate into the Stanislaus River in spring and early summer, where they hold for approximately 1 year before spawning (Hanni et al. 2006). Hannon and Deason (2008) have documented Pacific Lampreys spawning in the American River from between early January and late May, with peak spawning typically in early April. Spawning time is presumably similar in the Stanislaus River. Pacific Lamprey ammocoetes are expected to rear in the Stanislaus River for all or part of their 5- to 7-year freshwater residence. Data from rotary screw trapping in the nearby Mokelumne and Tuolumne rivers suggest that outmigration of Pacific Lamprey generally occurs from early winter through early summer (Hanni et al. 2006). Catches of juvenile Pacific Lampreys in trawl surveys of the mainstem San Joaquin River, near the mouth of the Stanislaus River at Mossdale, occurred during winter and spring. Some outmigration likely occurs year-round, as observed at sites on the mainstem Sacramento River (Hanni et al. 2006). Significant numbers of lampreys of unknown species and unspecified life stage have been captured during rotary screw trapping on the Stanislaus River at Oakdale (FISHBIO 2007) and Caswell (Watry et al. 2007).

Striped Bass

Striped Bass occur in the Stanislaus River, and they support a sport fishery when adult fish migrate upstream to spawn. Striped Bass have been observed at Lovers Leap and at Knights Ferry from May through the end of June. These adult fish were observed in all habitats (USFWS 2002, Kennedy and Cannon 2005). The distribution of Striped Bass in the Stanislaus River is thought to be limited to downstream of the historic Knights Ferry Bridge due to a set of falls about 3 feet tall in the area (USFWS 2002).

American Shad

American Shad migrate up the Stanislaus River to spawn in the late spring and support a sport fishery during that period. American Shad have been observed on occasion from June through July at Lovers Leap (USFWS 2002, Kennedy and Cannon 2005). American Shad were found primarily in the faster habitats and were observed in schools of 20 or more (USFWS 2002).

9.3.4.17.2 Aquatic Habitat

Schneider et al. (2003) conducted hydrologic analysis of the Stanislaus River and found that New Melones Dam (built in 1979) and more than 30 smaller dams cumulatively impound 240 percent of average annual unimpaired runoff. Schneider et al. (2003) concluded that this has reduced winter floods and spring snow melt runoff, and increased summer base flows to supply irrigation demand. As a result, the frequency and extent of overbank flooding has been reduced.

Based on historical data and field measurements, Schneider et al. (2003) suggested that the channel had incised approximately 1 to 3 feet since dam construction, and that the discharge needed for overbank flows has approximately doubled.

With respect to the related need for geomorphic flows, Kondolf et al. (2001) estimated bedload mobilization flows in the Stanislaus River to be around 5,000 to 8,000 cfs to mobilize the median particle size of the channel bed material. Flows necessary to mobilize the bed material increased downstream from a minimal 280 cfs where gravel had been recently added near Goodwin Dam to about 5,800 cfs at Oakdale Recreation Area (Reclamation 2008a). Before construction of New Melones Dam, a bed-mobilizing flow of 5,000 to 8,000 cfs was equivalent to a 1.5- to 1.8-year return interval flow. Following construction of the dam, 5,000 cfs represents approximately a 5-year return interval flow, and 8,000 cfs exceeds all flows within the 21-year study period, 1979 to 1999 (maximum flow = 7,350 cfs on January 3, 1997). The probability of occurrence for a daily average flow exceeding 5,330 cfs (the pre-dam bankfull discharge) is 0.01 per year.

Low dissolved oxygen (DO) levels have been measured in the San Joaquin River, in particular in the Deep Water Ship Channel (DWSC) from the Port of Stockton seven miles downstream to Turner Cut (Lee and Jones-Lee 2003). These conditions are the result of increased residence time of water combined with high oxygen demand in the anthropogenically modified channel, which leads to DO depletion, particularly near the sediment-water interface (SJTA 2012). Despite these conditions, adult salmon and steelhead migration does not appear to be adversely impacted (Pyper et. al 2006). However, during the 1960s, Hallock et al. (1970) found that adult radio-tagged Chinook Salmon delayed their upstream migration whenever dissolved oxygen concentrations were less than 5 mg/L at Stockton. SWRCB D-1422 requires water to be released from New Melones Reservoir to maintain dissolved oxygen standards in the Stanislaus River, as described in Chapter 6, Surface Water Quality. It has been shown that low DO conditions in the San Joaquin River can be ameliorated somewhat through installation of the Head of the Old River Barrier which increases San Joaquin River flows (SJTA 2012).

Spawning and Rearing Habitat

Upstream dams have suppressed channel-forming flows that replenish spawning beds in the Stanislaus River (Kondolf et al. 1996). The physical presence of the dams impedes normal sediment transportation processes. Kondolf (et al. 2001) identified levels of sediment depletion at 20,000 cubic yards per year as a result of a variety of factors, including mining, and geomorphic processes associated with past and ongoing dam operations. In 2011, 5,000 tons of gravel were placed in Goodwin Canyon downstream of Goodwin Dam, of which around 70 percent was transported into nearby downstream areas during high flows (SOG 2012).

Extensive instream gravel mining removed large quantities of spawning habitat (Kondolf et al. 2001). Gravel mining also has resulted in instream mine pits that occur in the primary salmonid spawning areas, including a large, approximately

1-mile-long pit called the Oakdale Recreation Pond. Instream mine pits trap bedload sediment, store large volumes of sand and silt, and pass sediment-starved water downstream, where it typically erodes the channel bed and banks to regain its sediment load (Kondolf et al. 2001). Reclamation restores and replenishes spawning gravel and rearing habitat lost from the construction and operation of dams in the Stanislaus River to restore spawning habitat and remediate sediment related loss of geomorphic function, such as channel incision.

Floodplain Habitat

Kondolf et al. (2001) identified that floodplain terraces and point bars inundated before operation of New Melones Reservoir have become fossilized with fine material and thick riparian vegetation that is never rejuvenated by scouring flows. Channel forming flows in the 8,000-cfs range have occurred only twice since New Melones Reservoir began operation 28 years ago.

Based on historical data and field measurements, Schneider et al. (2003) suggested that the channel incised approximately 1 to 3 feet since dam construction, and that the discharge needed for overbank flows has approximately doubled. Without inundation, the floodplains cannot provide terrestrial food for juvenile salmon or organic matter that helps produce more food within the river. Increased flows required for inundation also have had the effect of further isolating floodplains from the channel, leading to the loss of floodplain habitats.

In 2011, a habitat restoration project to increase spawning habitat also restored 640 feet of remnant side channel habitat, allowing water to flow at the current 1.5-year return interval (575 cfs), in addition to three cross channels designed to inundate at higher flows (SOG 2011).

9.3.4.17.3 Fish Passage and Entrainment

Constructed in 1913, Goodwin Dam was probably the first permanent barrier to significantly affect anadromous fish access to upstream habitat in the Stanislaus River. Goodwin Dam had a fishway, but Chinook Salmon could seldom pass it, and other salmonids may have been similarly affected. Yoshiyama et al. (1996) estimated that historically Chinook Salmon and other salmonids had access to 113 miles of habitat, compared with 58 miles under current conditions.

There are numerous small, unscreened diversions on the lower Stanislaus River (Herren and Kawasaki 2001). The effects of these diversions on fish is not clear; however, in tracking the fate of 49 radio tagged fish, S.P. Cramer and Associates (1998) did not detect any entrainment at several moderately sized unscreened pumps in the lower Stanislaus River.

9.3.4.17.4 Predation

Areas of the Stanislaus River, including spawning riffles in the active channel, were mined for gravel and gold primarily between 1940 and 1970. The mined areas consist of long, deep ditches and large ponds that provide habitat for predators, such as Striped Bass, Sacramento Pikeminnow, Largemouth Bass, and Smallmouth Bass (Mesick 2002). Studies by S.P. Cramer and Associates (1998) documented predation on juvenile salmonids by bass in the Tuolumne and Stanislaus rivers. However, in its review of information, the SRFG (2004) concluded that the available studies and observations suggest that fish predators in the Stanislaus River may be limited to adult pikeminnow and Riffle Sculpin feeding on newly emerged fry, whereas Smallmouth Bass, Largemouth Bass, and possibly American Shad probably feed on relatively few parr that remain in the river during late spring and summer when water temperatures are high.

It is possible that predation is high for juveniles rearing in the deep-water ship channel in the Delta as observed by Pickard et al. (1982). Predation rates on hatchery-reared juveniles and tagged juveniles may be higher than those for naturally produced fish. TID/MID (1992, 2013), and TRTAC et al. (2006), have documented predation on salmonids by nonnative predatory fishes in the Tuolumne River, primarily in run-of-river gravel mining ponds and dredged areas. Sonke and Fuller (2012) reported the number of juvenile Chinook Salmon passing the rotary screw traps at Waterford (2006 to 2012) and Grayson (1995 to 2012) on the Tuolumne River. FISHBIO (2013) calculated the potential consumption of juvenile Chinook Salmon by predators in the reach between the Waterford and Grayson rotary screw traps in 2012 and found that consumption of juvenile Chinook Salmon in this reach could equal or exceed the number passing the Waterford trap. Based on their consumption calculations and the difference in estimated numbers of juvenile Chinook Salmon passing the Waterford and Grayson rotary screw traps, FISHBIO (2013) concluded that it is plausible that the majority of juvenile Chinook Salmon losses in this reach are due to predation. NMFS (2009a) noted that losses on the Stanislaus River have not been similarly quantified, but predation on fall-run Chinook Salmon smolts and steelhead by Striped Bass and Largemouth Bass has been documented.

9.3.4.18 San Luis Reservoir

San Luis Reservoir is located at the base of the foothills on the west side of the San Joaquin Valley in Merced County, as described in Chapter 5, Surface Water Resources and Water Supplies. Water from the Delta is delivered to San Luis Reservoir via the California Aqueduct and Delta-Mendota Canal for storage.

San Luis Reservoir and O’Neill Forebay support several species of fish that have become established within the system, either by direct introduction or from the Delta system via pumping from the California Aqueduct and Delta-Mendota Canal. Striped Bass are the predominant species in San Luis Reservoir (DWR 1987) and support a recreational fishery. Other species include Sacramento Blackfish, American Shad, Threadfin Shad, Largemouth Bass, Kokanee Salmon, Green Sunfish, Bluegill, White Sturgeon, and White Crappie.

There are no sensitive fish species in the San Luis Reservoir except, possibly, individuals entrained by the CVP and SWP projects in the Delta. These individuals have already been lost to their populations, as they cannot return to the Delta once entrained. Potentially occurring fish species with special status that may have been imported from the Delta include Chinook Salmon, Delta Smelt, Hardhead, and Sacramento Splittail (Reclamation and CSP 2013).

9.3.5 San Francisco Bay Area Region

Fish and aquatic habitat resources in the San Francisco Bay Area Region include habitat through San Francisco Bay and along the Pacific Ocean coast. The anadromous fish species discussed above use the Pacific Ocean as part of their life cycles. In addition, the Pacific Ocean supports the killer whale which relies upon Chinook Salmon (e.g., fall-run Chinook Salmon) for food.

The San Francisco Bay Area Region also includes fish habitat within reservoirs that store CVP and SWP water. CVP and SWP water supplies are stored in Contra Loma and San Justo reservoirs; the SWP Bethany Reservoir and Lake Del Valle; the Contra Costa Water District Los Vaqueros Reservoir; and the East Bay Municipal Utility District (EBMUD) Upper San Leandro, San Pablo, Briones, and Lafayette reservoirs and Lake Chabot. Many of these reservoirs also store water from local and regional water supplies. CVP and SWP water is generally not stored in reservoirs within Santa Clara County (SCVWD 2010).

9.3.5.1 Pacific Ocean Habitat of the Killer Whale

The Pacific Ocean along the coast of California is included in this description of the affected environment because of it provides habitat for the Southern Resident killer whale population. The effect of the action, however, is limited to changes in the number of Chinook Salmon produced in the Central Valley entering the Pacific Ocean, which contribute an important component of the killer whale diet.

Southern Resident killer whales are found primarily in the coastal waters offshore of British Columbia and Washington and Oregon in summer and fall (NMFS 2008). During winter, killer whales are sometimes found off the coast of central California and more frequently off the Washington coast (Independent Hilborn et al. 2012).

The 2005 NMFS endangerment listing (70 FR 69903) for the Southern Resident killer whale distinct population segment lists several factors that may be limiting the recovery of killer whales, including the quantity and quality of prey, accumulation of toxic contaminants, and sound and vessel disturbance. In the Recovery Plan for Southern Resident Killer Whales (*Orcinus orca*), NMFS (2008) posits that reduced prey availability forces whales to spend more time foraging, which may lead to reduced reproductive rates and higher mortality rates. Reduced food availability may lead to mobilization of fat stores, which can release stored contaminants and adversely affect reproduction or immune function (NMFS 2008).

The Independent Science Panel reported that Southern Resident killer whales depend on Chinook Salmon as a critical food resource (Independent Science Panel and ESSA Technologies 2012). Hanson et al. (2010) analyzed tissues from predation events and feces to confirm that Chinook Salmon were the most frequent prey item for killer whales in two regions of the whale's summer range off the coast of British Columbia and Washington state, representing over 90 percent of the diet in July and August. Samples indicated that when Southern Residents are in inland waters from May to September, they consume Chinook Salmon stocks that originate from regions including the Fraser River, Puget

Sound, the Central British Columbia Coast, West and East Vancouver Island, and Central Valley California (Hanson et al. 2010).

Significant changes in food availability for killer whales have occurred over the past 150 years, largely due to human impacts on prey species. Salmon abundance has been reduced over the entire range of the Southern Resident killer whales, from British Columbia to California. The Recovery Plan for Southern Resident Killer Whales (*Orcinus orca*) (NMFS 2008) indicates that wild salmon have declined primarily due to degraded aquatic ecosystems, overharvesting, and production of fish in hatcheries. The recovery plan supports restoration efforts to rebuild depleted salmon populations and other prey to ensure an adequate food base for Southern Resident killer whales.

Central Valley streams produce Chinook Salmon that contribute to the diet of Southern Resident killer whales. The number of Central Valley salmon that annually enter the ocean and survive to a size susceptible to predation by killer whales is not known. However, estimates of total Chinook Salmon production produced by the Comprehensive Assessment and Monitoring Program, administered by USFWS and Reclamation, provide an approximation of the size of the ocean population of Central Valley Chinook Salmon potentially available to killer whales. Since 1992, total production of fall-run Chinook Salmon ranged from 53,129 in 2009 to 1,436,928 in 2002 (Table 9.2). The term “total production” here represents the number of fish that returned from the ocean plus those that were taken as part of the commercial and sport fishery. It does not include natural mortality in the ocean, including salmon taken by killer whales.

Table 9.2 Total Production (Number of Individuals) of Central Valley Fall-run Chinook Salmon in the Pacific Ocean and Ocean Harvest 1992-2011

Year	Total Production	Ocean Harvest
1992	333,087	203,318
1993	553,617	352,913
1994	711,654	449,060
1995	1,391,357	994,194
1996	891,739	471,865
1997	1,146,471	679,151
1998	557,433	263,935
1999	795,768	316,873
2000	1,156,596	571,829
2001	976,034	218,424
2002	1,436,928	418,785
2003	1,019,686	297,140
2004	977,463	500,929
2005	874,670	356,514
2006	453,274	110,540
2007	202,311	87,528
2008	71,870	0
2009	53,129	0
2010	208,050	13,851
2011	329,092	57,224

Source: DOI 2012

9.3.5.2 Contra Loma Reservoir

The Contra Loma Reservoir is a CVP facility in Contra Costa County that provides offstream storage along the Contra Costa Canal. The 80-acre reservoir is part of 661-acre Contra Loma Regional Park and Antioch Community Park (Reclamation 2014b). There are currently 20 known fish species, including 8 species of game fish, in Contra Loma Reservoir. The East Bay Parks and Recreation District (EBRPD) and CDFW stock Rainbow Trout and Channel Catfish in the reservoir. The reservoir also supports self-sustaining populations of Largemouth Bass, crappie, Redear Sunfish, and Bluegill, which are also popular with anglers (Reclamation 2014b). Other species found include White Catfish, Threadfin Shad, Bigscale Logperch, Common Carp, Sacramento Blackfish, Warmouth, Green Sunfish, Goldfish, Prickly Sculpin, and Inland Silversides (Reclamation 2014b).

Many of the fish species present have been unintentionally introduced from the Delta via the Contra Costa Canal. Recently, the Rock Slough Fish Screen at the head of Contra Costa Canal was constructed to prevent the entrainment of federally protected species such as Delta Smelt at the Rock Slough Intake of the Contra Costa Canal. The new screen also minimizes fish entrainment and significantly reduces the potential for fish introductions into Contra Loma Reservoir from the Contra Costa Canal (Reclamation 2014b).

9.3.5.3 San Justo Reservoir

The San Justo Reservoir is a CVP facility in San Benito County that provides offstream storage as part of the San Felipe Division, as described in Chapter 5, Surface Water Resources and Water Supplies. Other than stocked Rainbow Trout, all of the fish and other aquatic organisms that have been observed in San Justo Reservoir are nonnative species (SBCWD 2012).

9.3.5.4 South Bay Aqueduct Reservoirs

Bethany Reservoir, Patterson Reservoir, and Lake Del Valle are SWP facilities associated with the South Bay Aqueduct in Alameda County, as described in Chapter 5, Surface Water Resources and Water Supplies. At Bethany Reservoir, anglers catch five types of bass (Spotted, White, Largemouth, Smallmouth, and Striped), crappie, catfish, and trout (CSP 2013). Presumably, many of the same species would be found in Patterson Reservoir. Lake Del Valle is stocked regularly with trout and catfish. Largemouth and Smallmouth Bass, Striped Bass, and panfish are also caught (EBPRD 2014).

9.3.5.5 Los Vaqueros Reservoir

Los Vaqueros Reservoir is a Contra Costa Water District offstream storage facility in Contra Costa County, as described in Chapter 5, Surface Water Resources and Water Supplies. Aquatic habitat quality for fish is low to moderate due to poorly developed cover vegetation along the shoreline. The reservoir has been stocked with more than 300,000 game fish, primarily Rainbow Trout and Kokanee Salmon. Other fish introduced to the reservoir include Striped Bass, Largemouth Bass, sunfish, Brown Bullhead, and Channel Catfish (Reclamation and CCWD 2011).

9.3.5.6 East Bay Municipal Utility District Reservoirs

The EBMUD reservoirs in Alameda and Contra Costa County used to store water within and near the EBMUD service area include Briones Reservoir, San Pablo Reservoir, Lafayette Reservoir, Upper San Leandro Reservoir, and Lake Chabot. Water stored in these reservoirs includes water from local watersheds, the Mokelumne River watershed, and CVP water supplies, as described in Chapter 5, Surface Water Resources and Water Supplies. San Pablo Reservoir is regularly stocked with trout and catfish (EBMUD 2014). Other species caught in the reservoir include crappie, Largemouth Bass, Smallmouth Bass, Spotted Bass, and carp (OEHHA 2009).

CDFW annually stocks trout in Lafayette Reservoir. Other species found in the reservoir include Bluegill, black bass, Black Crappie, and several species of catfish (Lafayette Chamber of Commerce 2014).

Lake Chabot is stocked with hatchery-raised Rainbow Trout and Channel Catfish by EBRPD and CDFW for recreational fishing. The lake also supports a popular nonnative, warm-water recreational fishery for Largemouth Bass, Bluegill, and Black Crappie. Some native trout escape from the Upper San Leandro Reservoir during spill events and likely end up in Lake Chabot (EBMUD 2013).

9.3.6 Central Coast Region

The Central Coast Region includes portions of San Luis Obispo and Santa Barbara counties served by the SWP. SWP water is delivered to southern Santa Barbara County communities through Cachuma Lake.

9.3.6.1 Cachuma Lake

Cachuma Lake is a facility owned and operated by Reclamation in Santa Barbara County. Cachuma Lake provides a variety of habitats for fish species, including deep-water areas, rocky drop-offs, shallow areas, and weed beds (wetland areas). Cachuma Lake and the upper Santa Ynez River are popular fishing areas that have been stocked with game fish by CDFW and the County of Santa Barbara. Native fish species in Cachuma Lake include steelhead/Rainbow Trout, Armored Three-Spine Stickleback, and Prickly Sculpin. Key game fish include Largemouth Bass, Smallmouth Bass, Bluegill, Green Sunfish, Redear Sunfish, Black Crappie, and White Crappie. Other species that have been identified in the lake include Channel Catfish, Black Bullhead, Threadfin Shad, goldfish, carp, and Mosquitofish (Reclamation 2010c).

9.3.7 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. There are six SWP reservoirs along the main canal, West Branch, and East Branch of the California Aqueduct and many other reservoirs owned and operated by regional and local agencies. The Metropolitan Water District of Southern California’s Diamond Valley Lake and Lake Skinner primarily store water from the SWP. Other reservoirs store SWP water, including United Water Conservation District’s Lake Piru; City of Escondido’s Dixon Lake; City of San Diego’s San Vicente Reservoir and Lower Otay Reservoir; Helix Water District’s Lake Jennings; and Sweetwater Authority’s Sweetwater Reservoir.

9.3.7.1 State Water Project Reservoirs

The SWP reservoirs include Quail Lake, Pyramid Lake, and Castaic Lake in Los Angeles County; Silverwood Lake and Crafton Hills Reservoir in San Bernardino County; and Lake Perris in Riverside County.

Although small compared to nearby Pyramid and Castaic lakes, Quail Lake’s 290 acres and 3 miles of shoreline offer shoreline fishing. Striped Bass, Channel Catfish, Blackfish, Tule Perch, Threadfin Shad, and Hitch have been found at Quail Lake (DWR 1997).

Pyramid Lake is located in the Angeles and Los Padres National Forests, about 60 miles northwest of downtown Los Angeles. Largemouth Bass, Smallmouth Bass, and Striped Bass as well as Bluegill, crappie, Brown Bullhead, Channel Catfish, and trout are caught by anglers in Pyramid Lake (OEHHA 2013a). Rainbow Trout, Bluegill, Green Sunfish, Largemouth Bass, catfish, and Prickly Sculpin are found in Piru Creek below the dam (DWR 2004d).

Castaic Lake supports a warm-water fishery for Striped Bass and Largemouth Bass. Bluegill and assorted minnows provide a forage base for the bass as well as being caught by anglers. CDFW maintains a Rainbow Trout fishery in Castaic Lake through stocking (DWR 2007).

Silverwood Lake is located in the San Bernardino National Forest and surrounded by the Silverwood Lake State Recreation Area at the edge of the Mojave Desert and at the base of the San Bernardino Mountains. Common sport fish caught in Silverwood Lake include stocked Rainbow Trout, Largemouth Bass, Bluegill, carp, crappie, catfish, and Striped Bass (CSP 2010, OEHHA 2013b). Other species found in the lake include blackfish, Brown Bullhead, Tui Chub, and Tule Perch (OEHHA 2013b).

The Crafton Hills Reservoir area includes 4.5 acres of open water and 1.9 acres of open space. One fish species, Mosquitofish, was observed in the reservoir (DWR 2009b).

Lake Perris is located within the Lake Perris State Recreation Area, which provides extensive recreational opportunities, as described in Chapter 15, Recreation Resources. Lake Perris is stocked with Rainbow Trout and managed as a recreational fishery. Common fish species in the lake include Largemouth Bass, Channel Catfish, Bluegill, Spotted Bass, Flathead Catfish, Green Sunfish, Redear Sunfish, and Black Crappie (DWR 2010). Other species found in the lake include Inland Silversides and Threadfin Shad (DWR 2007).

9.3.7.2 Non-SWP Reservoirs in Riverside County

Diamond Valley Lake and Lake Skinner in Riverside County are offstream storage facilities owned and operated by Metropolitan Water District of Southern California. These lakes are major reservoirs used to store SWP water. Diamond Valley Lake supports Largemouth Bass, Striped Bass, catfish, Redear Sunfish, Bluegill, and stocked Rainbow Trout (DVM 2014). Fish species found in Lake Skinner include Striped Bass, Largemouth Bass, carp, and Bluegill. The Metropolitan Water District also stocks catfish in summer and trout in winter (Riverside County 2014).

9.3.7.3 Non-SWP Reservoir in Ventura County

Lake Piru, located in Ventura County, is used to store SWP water by United Water Conservation District. Like Pyramid Lake upstream on Piru Creek, sport fish species in Lake Piru include trout, Largemouth Bass, catfish, crappie, Bluegill, and Redear Sunfish (CA Lakes 2014). Other species found there include Bigscale Logperch, Black Bullhead, carp, goldfish, Golden Shiner, Green Sunfish, and Inland Silversides (CalFish 2014).

9.3.7.4 Non-SWP Reservoirs in San Diego County

Reservoirs in San Diego County that are used to store SWP water include the City of Escondido's Dixon Lake; City of San Diego's San Vicente, El Capitan, and Lower Otay reservoirs; Helix Water District's Lake Jennings; and Sweetwater Authority's Sweetwater Reservoir.

Dixon Lake is located in the hills above the City of Escondido within the Escondido Multiple Habitat Conservation Plan area (City of Escondido 2012). Fish species found in Dixon Lake include Rainbow Trout, Channel Catfish, Bluegill, Largemouth Bass, Striped Bass, and Black Crappie (SDFish 2014).

San Vicente Reservoir has been stocked with various sport fish including sunfish, Largemouth Bass, Black Crappie, catfish, and Rainbow Trout. Other species found in the reservoir include Threadfin Shad and Prickly Sculpin (SDCWA and USACE 2008). El Capitan reservoir is stocked with Largemouth Bass, crappie, Bluegill, Channel Catfish, Blue Catfish, Green Sunfish, and Common Carp (City of San Diego 2014a). Fish species in Lower Otay Reservoir include Largemouth Bass, Bluegill, Black Crappie, White Crappie, Channel Catfish, Blue Catfish, White Catfish, and bullheads (City of San Diego 2014b).

Lake Jennings is regularly stocked with trout and Channel Catfish. Other species found in the lake are Bluegill, Largemouth Bass and Blue Catfish (SDFish 2015).

Eleven fish species were observed in Sweetwater Reservoir during biological surveys for the wetlands habitat recovery project, all of which were nonnative and typical of southern California warm-water lakes. Species observed include Channel Catfish, Threadfin Shad, Bluegill, and Largemouth Bass (Sweetwater Authority 2013).

9.3.7.5 Non-SWP Reservoir in San Bernardino County

Lake Arrowhead, in San Bernardino County, is used to store SWP water by the Lake Arrowhead Community Services District (County of San Bernardino 2011; LACSD 2014a, 2014b). Lake Arrowhead is a private lake, and its use is restricted to homeowners in a tract of land roughly 1 mile around the perimeter of the lake, known as Arrowhead Woods. Fish species found in the lake include trout, Kokanee Salmon, bass, catfish, crappie, sunfish, and carp.

9.3.7.6 Fish and Aquatic Resources During Drought

California is contending with its fourth consecutive year of drought where significant shortages in water supplies have profoundly influenced water use in the state, including environmental uses. The reduced water availability has depleted reservoir storage and the ability for operations to provide flow levels needed to support fish habitat within the river systems. In addition, the limited cold water held in CVP and SWP reservoirs has impaired the ability to manage water temperatures downstream. Similarly, the reduced flows in the Delta have resulted in shifts in salinity and water quality that influence the availability and quality of habitat for pelagic fishes as well as the factors that influence entrainment. As a consequence, the reduction in runoff and available water has likely compromised an already stressed aquatic ecosystem and may have further imperiled species that are threatened with or in danger of extinction.

As described in the sections above, many fish populations have been in decline over the last several years. There are undoubtedly multiple factors influencing this decline; however, the recent drought and actions taken to address the drought are clearly contributors. In the recent conditional approval by the SWRCB of Reclamation’s Temporary Urgency Change Petition (SWRCB 2015), the SWRCB summarized the effects of the recent drought conditions on aquatic resources based on a biological review conducted for the purposes of consultation with NMFS and USFWS. The summaries from that document (SWRCB 2015) for several key species are paraphrased below.

The population of winter-run Chinook salmon is currently at extreme risk. In 2014, due to a lack of ability to regulate water temperatures in September and October, high water temperatures in the Sacramento River reduced early life stage survival from Keswick to Red Bluff from a recent average of approximately 27 percent down to 5 percent in 2014. Consequently, 95 percent of the year class of wild winter-run Chinook was lost last year (Reclamation and DWR 2015). Temperature management was difficult again in 2015, which reduces this population’s ability to withstand environmental perturbations, especially during a prolonged drought when each of the existing brood years has been already negatively affected by drought conditions.

The 2014 spawning run of spring-run Chinook Salmon returning to the upper Sacramento River system also experienced significant impacts due to drought conditions as well as elevated temperatures on the Sacramento River and other tributaries. Similar to winter-run, spring-run Chinook Salmon eggs in the Sacramento River experienced significant and potentially complete mortality starting in early September 2014 due to high water temperatures downstream of Keswick. Extremely few juvenile spring-run Chinook Salmon were observed migrating downstream of the Sacramento River during high winter flows in 2015, when spring-run originating from the upper Sacramento River, Clear Creek, and other northern tributaries are typically observed, indicating that the population was significantly impacted. Similar concerns for spring-run Chinook Salmon exist this year as for winter-run. While spring-run have greater distribution and inhabit locations in addition to the Sacramento River, conditions on those streams are also expected to be poor due to the drought.

Steelhead have also likely been affected by the drought, but given the difficulty in sampling for these fish it is difficult to determine exactly how the species have been affected. Adult steelhead abundance is not estimated in the mainstem

Sacramento River or any waterways of the Central Valley. The drought conditions are causing increased stress to steelhead populations (with or without water project operations) from low flows causing reduced rearing and migratory habitat, increased water temperatures affecting survival, and likely higher than normal juvenile predation.

The effects of the drought are also reflected in Delta species. For example, recent population indices for Delta Smelt are at record low numbers. This is of particular concern given that most Delta Smelt do not survive to spawn more than one season and are thus for the most part an annual species. The fifth Spring Kodiak Trawl survey conducted the week of May 4, 2015, identified 4 adults in the Sacramento Deep Water Ship Channel, and one in Cache Slough. The fourth Spring Kodiak Trawl survey, conducted during the week of April 6, 2015, identified one adult, which was a record low for that survey (Smelt Working Group (SWG); 4 May 13 notes). According to the SWG, it appears fish density has become so low that the Spring Kodiak Trawl has reached or gone below its minimum effective detection ability (SWG; April 13 Notes). Additionally, in the final week (March 30) of supplemental USFWS sampling in the lower San Joaquin River, catch of adult Delta Smelt declined precipitously to zero in the final month of sampling.

In response to the drought and its adverse effects on aquatic resources, Reclamation is currently conditionally operating under the terms of a temporary urgency change petition that allows temporary changes to license and permit requirements imposed pursuant to SWRCB D-1641 to meet flow-dependent and water quality objectives to protect fish and wildlife beneficial uses. In compliance with the provisions of the BOs, Reclamation and the SWRCB have received concurrence on the changes from USFWS and NMFS (USFWS 2015, NMFS 2015).[4]

9.4 Impact Analysis

This section describes the potential mechanisms and analytical methods; results of the impact analyses; potential mitigation measures; and cumulative effects.

9.4.1 Potential Mechanisms and Analytical Methods

The impact analysis considers changes in the ecological attributes that affect fish and aquatic resources related to changes in CVP and SWP operations under the alternatives as compared to the No Action Alternative and the Second Basis of Comparison.

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[4] Additional information regarding CVP and SWP operations under a TUC Order issued on July 3, 2015, by the State Water Resources Control Board is provided at: http://www.waterboards.ca.gov/waterrights/water_issues/programs/drought/docs/tucp/2015/tucp_order070315.pdf.

9.4.1.1 CVP and SWP Reservoirs

Changes in CVP and SWP operations under the alternatives could result in changes in reservoir storage volumes, elevations, and water temperatures in the primary water supply reservoirs (i.e., Trinity Lake, Shasta Lake, Lake Oroville, Folsom Lake, New Melones Lake, and San Luis Reservoir). Variation in reservoir storage, elevation, and temperature is a function of water demand, water quality requirements, and inflow; these attributes also change based on the water-year type.

The downstream reservoirs (i.e., Lewiston Lake, Keswick Reservoir, Thermalito Forebay and Afterbay, Lake Natoma, and Tulloch Reservoir) are operated to maintain relatively stable water elevations. These types of operations would result in similar conditions in the No Action Alternative, Alternatives 1 through 5, and the Second Basis of Comparison. Therefore, changes at these reservoirs are not evaluated in this EIS.

9.4.1.1.1 Changes in CVP and SWP Reservoir Storage Volume

To evaluate changes in operation, changes in reservoir storage and elevation were estimated based upon modeled monthly average storage and reservoir elevation output from CalSim II for the entire 82-year period under the operations defined for each alternative, as described in Appendix 5A, CalSim II and DSM2 Modeling. The output of CalSim II served as input to the quantitative procedures described below for evaluation of changes in fish habitat and bass nesting success in CVP and SWP reservoirs.

The effects analysis in Chapter 5, Surface Water Resources and Water Supplies, includes a summary of the monthly storage in each major upstream reservoir in combination with a frequency of exceedance analysis for each month. Reservoir storage values are characterized based on results of CalSim II hydrologic modeling and presented as average monthly storage by water year type. Although aquatic habitat within the CVP and SWP water supply reservoirs is not thought to be limiting, storage volume is used as an indicator of how much habitat is available to fish species inhabiting these reservoirs.

9.4.1.1.2 Changes in CVP and SWP Reservoir Elevation

Seasonal temperature stratification is a dominant feature of these reservoirs. There are relatively distinct fish assemblages within the upper (warm water) and lower (cold water) habitat zones, with different feeding and reproductive behaviors. Flood control, water storage, and water delivery operations typically result in declining water elevations during the summer through the fall months, rising or stable elevations during the winter months, and rising elevations during the spring months, while storing precipitation and snowmelt runoff. During summer months, the relatively warm surface layer favors warm water fishes such as bass and catfish. Deeper layers are cooler and are suitable for cold water species. Drawdown of reservoir storage from June through October can diminish the volume of cold water, thereby reducing the amount of habitat for cold water fish species within these reservoirs during these months.

Reservoir storage and surface water elevations in the reservoirs from the CalSim II model were used to analyze potential effects on reservoir fishes. Water surface elevation in each reservoir was calculated from storage values and is presented as average end-of-month elevation by water year type.

Warm water fish species that inhabit the upper layer of these reservoirs may be affected by fluctuations in storage through changes in reservoir water surface elevations (WSELs). Stable or increasing WSEL during spring months (March through June) can contribute to increased reproductive success, young-of-the-year production, and juvenile growth rate of several warm water species, including the black basses. Conversely, reduced or variable WSEL due to reservoir drawdown during spring spawning months can cause reduced spawning success for warm water fishes through nest dewatering, egg desiccation, and physical disruption of spawning or nest guarding behaviors. Increases in WSEL are not thought to result in adverse effects on these species unless there is a corresponding decrease in water temperatures that can result in nest abandonment.

A conceptual approach was used to evaluate the effects of water surface elevation fluctuations on bass nests, based upon a relationship between black bass nest success and water surface elevation reductions developed by CDFW (Lee 1999) from research conducted on five California reservoirs. Lee (1999) examined the relationship between water surface elevation fluctuation rates and nesting success for black bass, and developed nest survival curves for Largemouth, Smallmouth, and Spotted bass. The equations corresponding to the curves are the following:

Largemouth Bass $Y = -56.378*\ln(X)-102.59$

Smallmouth Bass $Y = -46.466*\ln(X)-83.34$

Spotted Bass $Y = -79.095*\ln(X)-94.162$

Where: X is the fluctuation rate (m/day) and Y is the percentage of successful nests.

Based on the work by Lee (1999), the maximum receding water level rate providing 100 percent successful nesting varied among species, with receding water level rates of <0.02, <0.01, and <0.065 meters per day providing successful nesting of 100 percent of the Largemouth, Smallmouth, and Spotted bass nests, respectively. For this analysis, water surface elevations at the end of each month from the CalSim II model were used to calculate the monthly fluctuation rates, and derive the daily fluctuation rates used to compute the percentage of successful nests using the equations from Lee (1999).

CalSim II reports end-of-month (EOM) water surface elevations; therefore, water surface elevations from February to June were used in this analysis (i.e., March fluctuation rate = March EOM elevation – February EOM elevation). It was further assumed that the monthly change in elevation divided by the number of days in that month reflected the average daily fluctuation rate that was used as “X” in the above equations to compute the percentage of successful nests during that month. The percentages of successful bass nests were computed based on the equations from Lee (1999) for each month of the potential spawning season for these species.

Review of the available literature suggests that bass nest failure is highly variable between water bodies and between years but it is not uncommon to have up to 40 percent of bass nests fail (approximately 60 percent survival) (Scott and Crossman 1973). Many self-sustaining black bass populations in North America experience a nest success (i.e., the nest produces swim-up fry) rate of 21 to 96 percent, with many reporting survival rates in the 40 to 60 percent range (Forbes 1981; Hunt and Annett 2002; Steinhart 2004). This would suggest that much less than 100 percent survival is required to have a self-sustaining population. Based on the literature review, bass nest survival probability in excess of 40 percent is assumed to be sufficient to provide for a self-sustaining bass fishery. For this analysis, differences between alternatives were evaluated using the exceedance probability corresponding to the 40 percent level of survival based on the probability of exceedance over the 82-year CalSim II modeling time period.

9.4.1.2 Rivers

By altering reservoir storage and releases, changes in CVP and SWP operations under the alternatives would change flow and temperature regimes in downstream waterways. In turn, these alterations could affect fishery resources and important ecological processes on which the fish community depends.

9.4.1.2.1 Changes in Flows

Changes in flows, in and of themselves, do not constitute an effect on aquatic resources. However, changes in flow can affect the quantity and quality of aquatic habitats in rivers and have direct effects on fish species through stranding or dewatering events that occur when flows are reduced. In addition, changes in flows can result in a reduction in ecologically important geomorphic processes resulting from reduced frequency and magnitude of intermediate to high flows.

Changes in flow also can influence the frequency and duration of inundated floodplains (e.g., Yolo Bypass) that support salmonid rearing and conditions for other native fish species. With implementation of the physical actions under NMFS RPA Action I.6.1, the inundation regime in the Yolo Bypass will be modified and managed to better coincide with the presence of juvenile salmonids and with a greater frequency. While this action is included in every alternative, changes in flows in the Sacramento River at the Freemont Weir associated with the various alternatives could result in slight differences in the flows entering the bypass and changes in the amount of habitat available to rearing salmonids and other native fish species.

The effects analysis in Chapter 5, Surface Water Resources and Water Supplies, includes a summary of the monthly flows at various points downstream of the reservoirs in each major stream affected by project operations. Instream flows are characterized based on results of CalSim II hydrologic modeling and presented as both average monthly flows by month and water year type and monthly frequency of exceedance plots to allow examination of the entire range of simulation results for each of the alternatives as a means of evaluating differences among alternatives. Because the CalSim II model uses a monthly time step, it was determined that incremental changes of 5 percent or less were related to the uncertainties in the model processing. Therefore, flow changes of 5 percent or less are considered to be not substantially different, or "similar" in this comparative analysis.

To compare the operational flow regime and evaluate the potential effects on habitat for anadromous species inhabiting streams, it was necessary to determine the relationships between streamflow and habitat availability for each life stage of these species in the rivers in which flows may be altered by CVP and SWP operations.

A number of studies have been conducted using the models and techniques contained within the Instream Flow Incremental Methodology (IFIM) to establish these relationships in streams within the study area. The analytic variable provided by the IFIM is total habitat, in units of Weighted Useable Area (WUA), for each life stage (fry, juvenile and spawning) of each evaluation species (or race as applied to Chinook Salmon). Habitat (WUA) incorporates both macro- and microhabitat features. Macrohabitat features include changes in flow, and microhabitat features include the hydraulic and structural conditions (depth, velocity, substrate or cover) affected by flow which define the actual living space of the organisms. The total habitat available to a species/life stage at any streamflow is the area of overlap between available microhabitat and macrohabitat conditions. Because the combination of depths, velocities, and substrates preferred by species and life stages varies, WUA values at a given flow differ substantially for the species and life stages evaluated.

WUA-flow relationships were available only for some rivers for which simulated flows were available. Therefore, flow dependent habitat availability was evaluated quantitatively only for Clear Creek and the Sacramento, Feather, and American rivers, and was not reported for other rivers evaluated in this Draft EIS. Tables of the spawning habitat-discharge relationships used in the calculations of spawning WUA for these rivers are provided in Appendix 9E, Weighted Useable Area Analysis. Because the WUA-flow relationships developed by the most recent IFIM studies present WUA values within particular flow ranges at particular variable steps, it was often the case that the monthly flow for a particular reach fell between two flows for which there were WUA values. In these cases, the value was determined by linear interpolation between the available WUA values for the flows immediately below and above the target flow. When the target flow was lower than the lowermost flow for which a WUA value exists, the corresponding WUA value was determined by linear interpolation between a flow of zero and the lowermost flow for which a WUA value exists. When the target flow was higher than the highest flow for which a WUA value exists, the corresponding WUA value was determined by assuming the WUA value for the highest flow.

WUA values are calculated and presented only on a monthly time-step, and not as seasonal or annual values. WUA values based on the monthly CalSim II flows were prepared for detailed evaluation of the alternatives. Monthly WUA values are presented as the average total WUA in each river segment, for the entire 82-year simulation period and the average total WUA in each of five water year types for each alternative. Differences between the alternatives and the two bases of comparison (No Action Alternative and Second Basis of Comparison) are used to identify the effects of each alternative on habitat availability (WUA) for each species and life stage in each river. These comparisons were made only for the months in which the species and life stage are anticipated to be present in each river/reach based on the life history timing presented in Appendix 9B.

The ability to estimate sub-monthly WUA values is limited due to the monthly time-step of the CalSim II results. The monthly time-step is most limiting during the fall through spring seasons in areas downstream of tributaries, when flows can vary significantly on a daily basis due to hydrologic conditions. Hydrologic variability in the runoff and tributary flows cause significant variability of flows in the areas of interest for the WUA computations. During the periods of low flows, regulated flows from reservoir releases dampen the impact of daily variability of flows on WUA estimates. Because the WUA analysis uses output from the monthly time step CalSim II model, it was determined that incremental changes of 5 percent or less were related to the uncertainties in the model processing. Therefore, changes in WUA values of 5 percent or less are considered to be not substantially different, or “similar” in this comparative analysis.

9.4.1.2.2 Changes in Water Temperatures

Water temperatures in the rivers and streams downstream of the CVP and SWP reservoirs are influenced by factors such as reservoir cold water pool, elevation of reservoir release outlets, and seasonal atmospheric conditions. The level of water storage in a reservoir has a strong effect on the volume of cold water (cold water pool) in the reservoir and, in combination with the elevation of reservoir release outlets, the temperature of water released downstream. Storage levels are often lowest in the late summer and early fall, resulting in warmer waters released from the reservoir. During this time of year, ambient air temperatures contribute substantially to warming instream flows downstream of reservoirs. The summer and early fall are the times of year when river temperatures are most likely to rise above tolerance thresholds for steelhead and salmon.

The analysis of the effects of water temperature changes on fish was conducted using two approaches: 1) a comparison of average monthly water temperatures between the alternatives and the two bases of comparison (No Action Alternative and Second Basis), and 2) a comparison of average monthly water temperatures to established temperature objectives intended to be protective of fish. In addition, Reclamation’s salmon mortality model was applied in certain water bodies to examine the effects of temperature on salmon spawning and incubation. These approaches are described below.

Comparison of Average Monthly Water Temperatures between Alternatives

The analysis uses average water monthly temperatures to provide a comparison of the ability of operations considered under alternatives to meet water temperature objectives for various species. As described in Appendix 5A, Section 5A.A.3.6, water temperature modeling is subsequent to CalSim II modeling that simulates operations on a monthly basis; there are certain components in the temperature models that are downscaled to a daily time step (simulated or approximated hydrology). The results of those daily conditions are averaged to a monthly time step.

The effects analysis in Chapter 6, Surface Water Quality, includes a summary of the average monthly water temperature in each major stream downstream of CVP and SWP reservoirs in combination with a frequency of temperature exceedance analysis (see below) for each month. Water temperatures at various locations in each river were compared to determine whether mean monthly temperatures by water-year type were different between the alternatives and the two bases of comparison (No Action Alternative and Second Basis). Because the temperature models use inputs from the monthly-time-step CalSim II model, effects of real-time daily temperature management cannot be captured, even though the temperature models are capable of simulating on a sub-monthly timestep. Therefore, the analysis is based on monthly average temperature results. For this monthly analysis that uses two cascading models, it was determined that incremental changes of 0.5°F or less in mean monthly water temperatures would be within the model uncertainty. Therefore, changes of 0.5°F or less are considered to be not substantially different, or "similar" in this comparative analysis.

Comparison to Established Water Temperature Thresholds

The average monthly water temperature output from CalSim II does not allow a direct comparison to the temperature objectives identified in Table 9.3, and the effects of daily (or hourly) temperature swings are likely masked by the averaging process. Nonetheless, the average monthly water temperatures provide the basis for a coarse evaluation of the likelihood that temperature objectives (Table 9.3) would be exceeded. These objectives are used as thresholds in the temperature exceedance analysis where the frequency of exceedance (percent of years) is calculated over the 82-year CalSim II modeling period (Appendix 9N). Because average monthly water temperatures likely mask daily temperatures that could exceed important thresholds, any difference in the frequency of threshold exceedance was considered important and could be indicative of a biological effect on the species/life stage for which the objective was established. While likely effects from temperature on early life stages occur at a shorter temporal scale than can be captured in these models, comparative analyses are useful for looking at long term impacts over numerous water years and types.

1 **Table 9.3 Water Temperature Objectives**

Compliance Location	Year Types	Dates	Temperature Objective (°F)	Purpose
Trinity River				
Lewiston Dam Release	All Year Types	July–Sep	< 60	Spring-run Chinook Salmon holding
		Sep	< 56	Spring-run Chinook Salmon spawning
Lewiston Dam Release	All Year Types	Oct–Dec	< 56	Chinook Salmon, Coho Salmon, and steelhead spawning
Clear Creek				
Igo W	All Year Types	June–Sep 15	60	Spring-run Chinook Salmon holding and rearing
		Sep 15-Oct	56	Spring-run and fall-run Chinook Salmon spawning and egg incubation
Sacramento River				
Keswick Release	All Year Types	May–Sep	56	Winter- and spring-run Chinook Salmon spawning and egg incubation
Balls Ferry	All Year Types	May–Sep	56	Winter- and spring-run Chinook Salmon spawning and egg incubation
Bend Bridge	All Year Types	May–Sep	56	Winter- and spring-run Chinook Salmon spawning and egg incubation
			63	Green sturgeon spawning, incubation, and rearing
Red Bluff	All Year Types	Oct–Apr	56	Spring-, fall-, and late fall–run Chinook Salmon spawning and egg incubation
Hamilton City	All Year Types	Mar–Jun	61 (optimal), 68 (lethal)	White Sturgeon spawning and egg incubation
Feather River				
Robinson Riffle	All Year Types	Sep–Apr	56	Spring-run Chinook Salmon and steelhead spawning and incubation
		May–Aug	63	Spring-run Chinook Salmon and steelhead rearing

Compliance Location	Year Types	Dates	Temperature Objective (°F)	Purpose
Gridley Bridge	All Year Types	Oct–Apr	56	Fall- and late fall–run Chinook Salmon spawning and steelhead rearing
		May–Sep	64	Green sturgeon spawning, incubation, and rearing
American River				
Watt Avenue Bridge	All Year Types	May–Oct	65	Juvenile steelhead rearing
Stanislaus River				
Orange Blossom Bridge	All Year Types	Oct–Dec	56	Adult steelhead migration
		Jan– May	57	Steelhead smoltification
		Jan-May	55	Steelhead spawning and incubation
		Jun-Sep	65	Juvenile steelhead rearing
Knights Ferry	All Year Types	Jan-May	52	Steelhead smoltification

Changes in Egg Mortality

Water temperatures also affect the survival of various life stages of the focal species. Reclamation’s salmon mortality model (Appendix 9C, Reclamation Salmon Mortality Model Analysis Documentation) was used to estimate water temperature induced mortality in the early life stages (pre-spawned eggs, fertilized eggs, and pre-emergent fry) of salmonids in five rivers: Trinity, Sacramento, Feather, American, and Stanislaus, based on output from the temperature models. The salmon mortality model is limited to temperature effects on early life stages of Chinook Salmon. It does not evaluate potential direct or indirect temperature impacts on later life stages, such as emergent fry, smolts, juvenile out-migrants, or adults. Also, it does not consider other factors that may affect salmon mortality, such as in-stream flows, gravel sedimentation, diversion structures, predation, and ocean harvest. Differences between alternatives are assessed based on changes in the percent egg mortality by river over the entire 82-year CalSim II simulation period and by water year type (based on 40-30-30 indexing). Because the salmon mortality model uses output from the temperature models that are downscaled from the monthly time step CalSim II model, it was determined that incremental changes in egg mortality of 5 percent or less were related to the uncertainties in the model processing. Therefore, changes in egg mortality of 5 percent or less are considered to be not substantially different, or "similar" in this comparative analysis.

9.4.1.3 Delta

Changes in CVP and SWP operations under the alternatives would affect Delta conditions primarily through changes in volume and timing of upstream storage releases and diversions, Delta exports and diversions, and DCC operations. Environmental conditions such as water temperature, predation, food production and availability, competition with introduced exotic fish and invertebrate species, and pollutant concentrations all contribute to interactive, cumulative conditions that have substantial effects on aquatic resources in the Delta.

9.4.1.3.1 Changes in Volume and Timing of Flows through the Delta

Operations of the CVP DCC and intake facilities owned by the CVP, SWP, local agencies, and private parties affect Delta hydrologic flow regimes. The largest effects of flow management in the Delta related to aquatic resources are the modification of winter and spring inflows and outflows of the Delta, and the introduction of net cross-Delta and net reverse flows in some Delta channels that can alter fish movement patterns. Seasonal flows play an especially important role in determining the reproductive success and survival of many estuarine species including salmon, Striped Bass, American Shad, Delta Smelt, Longfin Smelt, and Sacramento Splittail. In addition, changes in Delta outflow influence the abundance and distribution of fish and invertebrates in the bay through changes in salinity, currents, nutrient levels, and pollutant concentrations. Altered flows through the Delta as a result of changes in CVP and SWP operations affect water residence time, an important physical property that can influence the ability of phytoplankton biomass to build up over time, with implications for higher trophic level consumers such as fish.

9.4.1.3.2 Changes in Water Quality

Changes in water quality due to CVP and SWP operations under the alternatives would affect aquatic resources in the Delta primarily through changes in water temperatures, salinity, nutrient levels, pollutant concentrations and turbidity. Changes in CVP and SWP operations can increase Delta water temperatures by warmer reservoir releases and to a lesser extent, by reducing quantities of freshwater inflow and by modifying tidal and ground water hydraulics. Changes in CVP and SWP operations also can affect the location of the low salinity zone (position of X2), especially during periods of low inflows and high water exports (i.e., low outflow conditions) in drier water years. Nutrients, essential components of terrestrial and aquatic environments because they provide a resource base for primary producers, and pollutants such as selenium and mercury could be affected by changes in CVP and SWP operations. Turbidity is an important water quality component in the Delta that could be affected by changes in operation. Changes in turbidity affect food web dynamics through attenuation of light in the water column and altering predation success.

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. A more detailed overview of the DSM2 model and input assumptions is presented in Appendix 5A, CalSim II and DSM2 Modeling.

The Delta boundary flows and exports from CalSim II are used as input to the DSM2 Delta hydrodynamic and water quality models to estimate tidally-based flows, stage, velocity, and salt transport within the estuary. Because CalSim II operations are simulated on a monthly basis, the DSM2 model would not be able to capture daily operations and therefore the DSM2 outputs are presented on a monthly basis, as described in Appendix 5A, CalSim II and DSM2 Modeling.

DSM2 HYDRO outputs are used to predict changes in flow rates and depths. The QUAL module of DSM2 simulates fate and transport of conservative and non-conservative water quality constituents, including salts, given a flow field simulated by HYDRO. Chloride and bromide concentrations are estimated using relationships based on DSM2 EC results, as described in Appendix 6E, Analysis of Delta Salinity Indicators.

The CalSim II outputs described above that estimate the position X2 were used along with temperature to generally assess effects on Striped Bass and American Shad. Kimmerer (2002) noted that Striped Bass survival is negatively correlated with April – June X2 values, although the analysis was inconclusive on the mechanisms contributing to this relationship. Kimmerer (2009) noted that Delta Smelt and Striped Bass had more negative slopes in the habitat-X2 relationship for surveys conducted in spring to early summer months than other surveys. They also noted that the slopes for abundance–X2 and habitat–X2 were similar for American Shad and for Striped Bass, and that the habitat relationships to X2 appeared consistent with their relationships of abundance (or survival) to X2. Thus, Kimmerer et al. (2009) contended that this similarity provides some support for the notion that increasing habitat quantity as defined by salinity could be one mechanism to explain the X2 relationship for these species. Based on this relationship, the position of X2 was used as general indicator of habitat for Striped Bass and American Shad. Alternatives that resulted in a more westerly position of X2 relative to the bases of comparison were considered to have less potential for adverse effect, whereas those with a more easterly position would have a greater potential for adverse effect.

9.4.1.3.3 Changes in Fish Entrainment

Changes in CVP and SWP operations can affect through-Delta survival of migratory (e.g., salmonids) and resident (e.g., Delta and Longfin smelt) fish species through changes in the level of entrainment at CVP and SWP export pumping facilities. The south Delta CVP and SWP facilities are the largest water diversions in the Delta and in the past, have entrained large numbers of Delta fish species. Tides, salinity, turbidity, in-flow, meteorological conditions, season, habitat conditions, and project exports all have the potential to influence fish movement, currents, and ultimately the level of entrainment and fish passage success and survival. Entrainment risk for fish also tends to increase with increased reverse flows in Old and Middle rivers.

The potential for entrainment of salmonids migrating through the Delta was analyzed using predicted monthly salvage of salmonids from January through June using statistical relationships reported in Zeug and Cavallo (2014). In that analysis, salvage at the State Water Project and Central Valley Project was modeled as a function of physical, biological and hydrologic variables (see Appendix 9M for additional detail).

Results of the analysis are presented in box-whisker plots showing the median, central 50 percent probability, and range of simulated data. The comparison between alternatives relied on interpretation of these plots to distinguish differences in the median values as follows: (1) when the medians are nearly identical or the central 50 percent probabilities (i.e., the boxes) overlap completely, the medians were considered “similar;” (2) when the medians and box were offset, but the median values were within the range represented by the contrasting alternative’s box, the medians were considered “slightly” different; (3) when the median of one alternative was outside of the contrasting alternative’s box, but the boxes overlapped, the alternatives were considered “moderately” different; and (4) when the median of one alternative was outside of the contrasting alternative’s box, and the boxes did not overlap, the medians were considered “substantially” different.

In evaluating the potential for entrainment of Delta Smelt, as influenced by OMR flows under the alternatives, the USFWS (2008) regression model based on Kimmerer (2008) was used to estimate potential entrainment of Delta Smelt. The equation developed by Kimmerer (2008) is based on the average December through March OMR flow (in units of cfs) as predicted by the CalSim II model, and yields the percentage of adult Delta Smelt that may become entrained in the pumps. Further review by Kimmerer (2011) determined that the above equation has an upward bias, such that the results were reduced by 24 percent to correct this bias. In the event that a negative entrainment percentage was calculated, the result was changed to zero.

Changes in CVP and SWP operations under the alternatives could also change entrainment of larvae and early juvenile Delta Smelt. Larvae and early juvenile Delta Smelt are most prevalent in the Delta in the spring months of March through June. The USFWS (2008) regression model based on Kimmerer (2008) was used to calculate the percentage entrainment of larval and early juvenile Delta Smelt in Banks and Jones Pumping Plants. This regression is dependent on two variables: March through June average OMR flow (in cfs) and March through June average X2 position (in km). OMR and X2 values predicted by the CalSim II model for each alternative were used in estimating the entrainment loss. In the event that a negative entrainment percentage was calculated, the result was changed to zero.

In this study, the percent entrainment values estimated for Delta Smelt are used as a tool to compare the alternatives, as one of the factors that would indicate conditions that might benefit or contribute to adverse effects on Delta Smelt. Because the regression analysis uses flow output from the monthly time step CalSim II model and the confidence intervals on the regression parameters are somewhat broad, it was determined that incremental changes in entrainment estimates of 5 percent or less were within the model uncertainty. Therefore, changes in entrainment of less than 5 percent are considered to be not substantially different, or “similar” in this comparative analysis. One limitation of this approach is that it does not reflect the benefit that some of the alternatives might realize through adaptive management of OMR flows to further reduce potential entrainment, based on input from the Smelt Working Group.

9.4.1.3.4 Changes in Fish Passage and Routing

Changes in CVP and SWP operations can affect through-Delta survival of migratory (e.g., salmonids) and resident (e.g., Delta and Longfin smelt) fish species through changes in passage conditions and routing. For example, changes in operation of the DCC affects the volume of water diverted into the Mokelumne River distributary channels toward the central and south Delta. Operation of the south Delta intake facilities, including facilities owned by the CVP and SWP and Contra Costa Water District, contribute to reverse flow conditions in Old and Middle rivers.

Changes in salmonid passage and routing were evaluated using the Delta Passage Model (DPM) and an analysis of Delta hydrodynamics and junction entrainment, as described below. The DPM is based on a detailed accounting of migratory pathways and reach-specific mortality as Chinook salmon smolts travel through a simplified network of reaches and junctions (see Appendix 9J for additional detail). Model output is expressed as through Delta survival of salmon smolts.

The key assumption in the Delta Hydrodynamic analysis is that the proportion of positive velocities in a channel, measured at a monthly time step, is an indicator of the likelihood that juvenile anadromous fish will successfully migrate through that channel towards the ocean (see Appendix 9K for additional detail). The analysis of junction entrainment used a regression based on predicted entrainment into a distributary and the proportion of flow into the distributary to predict the daily probability of fish entrainment (see Appendix 9L for additional detail).

Results of the Delta hydrodynamics and junction entrainment analysis are presented in box-whisker plots showing the median, central 50 percent probability, and range of simulated data. The comparison between alternatives relied on interpretation of these plots to distinguish differences in the median values as described above for changes in fish entrainment.

9.4.1.3.5 Changes in Delta Smelt Habitat (X2 Location)

Changes in CVP and SWP operations under the alternatives could change the location of Fall X2 position (in September through December) as an indicator of available habitat for Delta Smelt. Feyrer et al. (2010) used X2 location as an indicator of the extent of habitat available with suitable salinity and water transparency for the rearing of older juvenile Delta Smelt. Feyrer et al. (2010) concluded that when X2 is located downstream (west) of the confluence of the Sacramento and San Joaquin Rivers, at a distance of 70 to 80 km from the Golden Gate Bridge, there is a larger area of suitable habitat. The overlap of the low salinity zone (or X2) with the Suisun Bay/Marsh results in a two-fold increase in the habitat index (Feyrer et al 2010); however others (see Manly et al. 2015) have questioned the use of outflow and X2 location as an indicator of Delta Smelt habitat because other factors may be influencing survival.

To evaluate fall abiotic habitat availability for Delta Smelt under the alternatives, X2 values (in km) simulated in the CalSim II model for each alternative were averaged over September to December, and compared for differences. There are uncertainties and limitations associated with this approach, e.g., it does not evaluate other factors that influence the quality or quantity of habitat available for Delta Smelt (e.g., turbidity, temperature, food availability), nor does it take into account the relative abundance of Delta Smelt that might benefit from the available habitat in the simulated X2 areas, in any given year. Other scientists have developed and described life cycle models to evaluate Delta Smelt population responses to changes in flow-related variables (e.g., Maunder and Deriso 2011; Rose et al. 2013 a, b), but these life cycle modeling approaches were not selected for use in the current study. The life cycle model developed by Rose et al. (2013a, b) could not be used in this analysis because it uses a wide array of daily data, many of the assumptions and parameter values were based on judgment, and the model was not designed for forecasting future Delta Smelt population abundances. The model was designed mostly for exploring hypothesis about factors affecting Delta smelt populations dynamics, which is not suitable for a comparative analysis of operational scenarios under the alternatives. Moreover, Reed et al. (2014) noted that "*To date, these models have not been fully vetted and evaluated sufficiently to be used for direct management applications*." In this study, simulated fall X2 values are used as a tool to compare the alternatives, as one of the factors that would indicate available suitable habitat to benefit Delta Smelt.

9.4.1.3.6 Changes in Salmonid Production

Collectively, factors such as flow, temperature, and habitat availability affect the population dynamics of anadromous fish species during their freshwater life stages. Three different models were used to assess changes in salmonid production potential: 1) SALMOD; 2) the Interactive Object-Oriented Simulation (IOS) model for winter-run Chinook Salmon; and 3) the Oncorhynchus Bayesian Analysis (OBAN) model for winter-run Chinook Salmon.

Comparison of Annual Production Using SALMOD

The SALMOD model (Appendix 9D, SALMOD Analysis Documentation) was used to assess changes in the annual production potential of four races of Chinook Salmon in the Sacramento River. The primary assumption of the model is that egg and fish mortality is directly proportional to spatially and temporally variable habitat limitations, such as water temperatures, which themselves are functions of operational variables (timing and quantity of flow) and meteorological variables, such as air temperature. SALMOD is a spatially explicit model that characterizes habitat value and carrying capacity using the hydraulic and thermal properties of individual habitat units. Inputs to SALMOD include flow, water temperature, spawning distributions, spawn timing by salmon race, and the number of spawners provided by the user (e.g., recent average escapement).

Annual production potential or the number of outmigrants, annual mortality, length, and weight of the smolts are some of the reporting metrics available from SALMOD. The production numbers obtained from SALMOD are best used as an index in comparing to a specified baseline condition rather than absolute values. Differences between alternatives are assessed based on changes in the annual production potential for each species by river by water year type. Because SALMOD uses flows and output from the water temperature models that are downscaled from the monthly time step CalSim II model, it was determined that incremental changes in production of 5 percent or less were related to the uncertainties in the model processing. Therefore, changes in production of 5 percent or less are considered to be not substantially different, or “similar” in this comparative analysis.

Comparison of Annual Winter-run Chinook Salmon Escapement Using IOS

IOS is a stochastic life cycle simulation model for winter run Chinook Salmon in the Sacramento River. The IOS model is composed of six model stages that are arranged sequentially to account for the entire life cycle of winter run, from eggs to returning spawners. The primary output from the IOS model is escapement, the total number of winter-run Chinook Salmon that leave the ocean and return to the Sacramento River to spawn. Differences between alternatives are assessed based on changes in the median annual escapement and the range of escapement values encompassed in the first and second quartiles (25 to 75 percent of years) over the 82-year CalSim II simulation period. The IOS model uses scenario-specific daily DSM2, CalSim II, and Sacramento River Basin Water Temperature Model (HEC-5Q) data as model input. Because IOS uses output from the monthly time step CalSim II model, or other models downscaled from CalSim II, as input, it was determined that incremental changes in escapement estimates of 5 percent or less in were related to the uncertainties in the model processing. Therefore, changes in escapment of 5 percent or less are considered to be not substantially different, or “similar” in this comparative analysis.

Comparison of Annual Winter-run Chinook Salmon Escapement Using OBAN

The Oncorhynchus Bayesian Analysis (OBAN) is a model that uses statistical relationships between historical patterns in winter-run Chinook salmon abundance and a number of other parameters that covary with abundance to predict future population abundance. The model determines the effects of water temperature, harvest, exports, striped bass abundance, and offshore upwelling using historical abundance data. The set of parameters, called covariates, that provided the best model fit was retained for the full model. The model then uses predicted future values of these parameters, primarily from CalSim II and temperature model outputs, to predict future patterns in Chinook salmon population abundance (escapement). Because OBAN uses output from the monthly time step CalSim II model, or other models downscaled from CalSim II, as input, it was determined that incremental changes in escapement estimates of 5 percent or less were related to the uncertainties in the model processing. Therefore, changes in escapement of 5 percent or less are considered to be not substantially different, or “similar” in this comparative analysis.

9.4.1.3.7 Changes in Sturgeon Year Class Strength

Changes in CVP and SWP operations can affect sturgeon species through changes in flows through the Delta that, in turn, affect the year class strength of both Green Sturgeon and White Sturgeon. Estimated Delta outflow from the CalSim II model was used to analyze the potential effects on sturgeon using the hypothesized relationship between Delta outflow and the age-0 Year Class Index (YCI) from the Bay Study in the presentation by Gingras et al. (2014). For this analysis, the mean Delta outflow during the March to July period for each year was calculated from the CalSim II output and used as an indicator of potential year class strength. Because the sturgeon analysis uses flow output from the monthly time step CalSim II model, it was determined that incremental changes in mean (March to July) Delta outflow of 5 percent or less were related to the uncertainties in the model processing. Therefore, changes in Delta outflow of less than 5 percent are considered to be not substantially different, or “similar” in this comparative analysis.

Mean (March to July) Delta outflow was also used as an indicator of the likelihood of producing a strong year class of sturgeon by examining the number of years (over the 82-year CalSim II simulation) that mean (March-July) Delta outflow would exceed a threshold of 50,000 cfs. Changes in the number of years exceeding the threshold was considered to have a potential effect on sturgeon.

9.4.1.4 Constructed Water Supply Facilities that Convey and Store CVP and SWP Water

The distribution system for water exported by CVP and SWP includes hundreds of miles of canals and numerous reservoirs designed to help regulate the flow of water to the areas where the water is used. Many of these canals and reservoirs support fish that were entrained into the system or intentionally stocked for recreational purposes, and changes in export deliveries could influence the quality of the aquatic habitat in these constructed water bodies. These constructed water bodies do not support important populations of native fish species and the management of flows is under the control of the entities that receive the water. Because many of the reservoirs also store water from non-CVP and SWP water supplies; it is difficult to predict changes in the aquatic habitat related to changes in CVP and SWP water supplies. Therefore, the potential effects of operation of these facilities on fish and aquatic resources are not addressed further in this EIS.

9.4.1.5 Analysis of Provision of Fish Passage

As described previously in the Affected Environment section, Shasta, Folsom, and New Melones dams and their associated downstream re-regulating reservoirs permanently blocked salmonid access to upper watersheds and effectively removed many miles of suitable habitat. These barriers particularly influenced populations of winter-run and spring-run Chinook Salmon and steelhead because their life history strategies are adapted to accessing higher elevation river reaches and tributaries to successfully spawn and rear, as well as for oversummering. Improving passage would increase the amount of available habitat, including access to colder headwaters, which would be particularly important considering anticipated climate change scenarios. Improved fish passage is not included under the Second Basin of Comparison or Alternative 2.

9.4.1.6 Analysis of Trap and Haul Program

Poor survival of juvenile salmonids in the Sacramento-San Joaquin Delta has been hypothesized as a major contributor to declines in the number of returning adults and may be a significant impediment to the recovery of threatened or endangered populations (NOAA 2009). Alternative 3 and Alternative 4 contain a trap and haul program for juvenile salmonids entering the Delta from the San Joaquin River, similar to the program in place on the Columbia River in Oregon. This action would not be implemented under the No Action Alternative, Second Basis of Comparison, or other action alternatives, with the exception of Alternatives 3 and 4. Background information on the trap and haul program associated with Alternatives 3 and 4 is provided in Appendix 9O and was used in the qualitative assessment of the trap and haul program under Alternatives 3 and 4.

9.4.1.7 Analysis of Predator Control Programs

As described in Chapter 3, Description of Alternatives, Alternatives 3 and 4 include predator control actions designed to reduce predation on salmonids and Delta Smelt, primarily within the Delta. Predator control measures are included in Alternatives 3 and 4, including an increased bag limit and minimum size limit for Striped Bass and black bass. The proposed bag and size limits are intended and expected to encourage more fishing effort for and greater harvest of Striped Bass and black bass, resulting in a reduction in the Striped Bass and black bass populations throughout the Delta. In addition, a sport reward program for Sacramento Pikeminnow would be implemented to encourage fishing for and removal of this predatory species. These two actions would not be implemented under the No Action Alternative, Second Basis of Comparison, or other action alternatives, with the exception of Alternatives 3 and 4.

9.4.1.8 Analysis of Ocean Salmon Harvest Restrictions

As described in Chapter 3, Description of Alternatives, Alternatives 3 and 4 include restrictions on the annual ocean Chinook Salmon harvest, which is intended to minimize harvest mortality of natural origin Central Valley Chinook Salmon, including fall-run Chinook Salmon, by evaluating and modifying ocean harvest for consistency with Viable Salmonid Population[5] standards. This would include working with the Pacific Fisheries Management Council (PFMC), CDFW, and NMFS to impose salmon harvest restrictions to reduce by-catch of winter-run and spring-run Chinook Salmon to less than 10 percent of age-3 cohort in all years.

The salmon ocean fishery off the coast of California is regulated by the PFMC, which establishes the annual catch limit to optimize overall benefits, particularly with regard to food production, recreation, and ecosystem protection. An annual catch limit generally is based on achieving the maximum sustained yield from the fishery, but also takes into account the effects of uncertainty; management imprecision; the need to rebuild stocks; and other relevant economic, social, and ecological factors. Compliance with the ESA, other laws, and treaties also may affect the annual catch limit. Each year, the maximum allowable harvest (i.e., maximum number of fish caught) is determined based on the abundance of fish spawning in the previous year. Depending on the number of spawning fish, different formulas for calculating the maximum allowable harvest (i.e., control rules) are used. These rules calculate the maximum allowable harvest as a percentage of the number of spawning fish, and are designed to maximize the yield of fish from a stock while preventing overfishing. The annual catch limit may be set at or below the maximum allowable harvest.

Reduction of the annual catch limit could directly influence the number of adult salmon reaching their natal streams to spawn, which could affect the number of salmon annually produced in Central Valley streams and the Trinity River. Harvest restrictions would be implemented under Alternatives 3 and 4, but would not be implemented under the No Action Alternative, Second Basis of Comparison, or other action alternatives.

9.4.1.9 Approach to Analyzing the Effects of Alternatives on Fish

The analysis of the effects of changes in operation of the CVP and SWP on fish and aquatic resources in this EIS is influenced by numerous factors related to the complexity of the ecosystem, changes within the system (e.g., climate change and species population trends), and the imprecision of operational controls and resolution in modeling tools. These factors are further complicated by the scientific uncertainty about some fundamental aspects of aquatic species life history and how these species respond to changes in the system, as well as sometimes competing points of view on the interpretation of biological and physical data within the scientific community. In light of these factors, the analysis takes an approach that presents available information and model outputs, synthesizes the results, and draws logical conclusions on likely effects of the various alternatives. Where relevant and appropriate, the analysis attempts to

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[5] "A viable salmonid population (VSP)2 is an independent population of any Pacific salmonid (genus *Oncorhynchus*) that has a negligible risk of extinction due to threats from demographic variation (random or directional), local environmental variation, and genetic diversity changes (random or directional) over a 100-year time frame" (McElhany et al. 2000, pg. 2).

identify the level of uncertainty and qualify effect conclusions where competing hypotheses may exist.

Many modeling tools have been developed to evaluate changes in CVP and SWP water management, and as a result, multiple sources of information are available to characterize conditions (e.g., water temperature, flows, reservoir storage). Most of these modeling tools explain or provide insight on one or two of the factors affecting the species, while some tools are more integrative (e.g., SALMOD) and capture multiple relationships among physical conditions and biological responses. Where integrative models were available, these were relied upon more than evaluation of the individual components. For species where these tools were not available, the analysis used a preponderance of evidence approach that drew conclusions based on trends indicated by the majority of the information. This approach assembled the full range of available information and model outputs and determined the direction (neutral, positive, or negative) of effect supported by the information.

For each focal species where sufficient information was available, the analysis includes an effects summary that presents the EIS authors' conclusions for that species and describes the rationale for the conclusion. It also presents a general indication of the level of uncertainty regarding the conclusion and presents qualifying information where disagreement in the scientific community may exist for more complete disclosure.

Because of the multiple model outputs, the body of the impact analysis contains a considerable amount of information, which is intended to summarize for the benefit of the reader, while leaving most of the detail in the appendices. The narrative contained in the body of the document and the model results in the appendices are intended to be used in concert in reviewing this EIS.

9.4.2 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. However, the changes to aquatic resources 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.

9.4.2.1 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

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.

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 under the No Action Alternative and the Second Basis of Comparison. However, the CVP and SWP water deliveries would be less under the No Action Alternative as compared to the Second Basis of Comparison, as described in Chapter 5, Surface Water Resources and Water Supplies, which could result in more crop idling.

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 aquatic resources, 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 USFWS BO and 2009 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 would affect aquatic resources, including:

- Habitat Restoration includes 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.
  - 2008 USFWS BO RPA Component 4 (Action 6). Habitat Restoration.
  - 2009 NMFS BO RPA Action I.6.1. Restoration of Floodplain Habitat.

  - 2009 NMFS BO RPA Action I.6.2. Near-Term Actions at Liberty Island/Lower Cache Slough and Lower Yolo Bypass.
  - 2009 NMFS BO RPA Action I.6.3. Lower Putah Creek Enhancements.
  - 2009 NMFS BO RPA Action I.6.4. Improvements to Lisbon Weir.
  - 2009 NMFS BO RPA Action I.7. Reduce Migratory Delays and Loss of Salmon, Steelhead, and Sturgeon at Fremont Weir and Other Structures in the Yolo Bypass.
- 2009 NMFS BO RPA Action I.1.3. Clear Creek Spawning Gravel Augmentation.
- 2009 NMFS BO RPA Action I.1.4. Spring Creek Temperature Control Curtain Replacement.
- 2009 NMFS BO RPA Action I.2.6. Restore Battle Creek for Winter-Run, Spring-Run, and Central Valley Steelhead.
- 2009 NMFS BO RPA Action I.3.1. Operate Red Bluff Diversion Dam with Gates Out.
- 2009 NMFS BO RPA Action I.5. Funding for CVPIA Anadromous Fish Screen Program.
- 2009 NMFS BO RPA Action II.1. Lower American River Flow Management.

Implementation of these common actions are described in more detail in this section under the No Action Alternative and referred under the discussion of the Second Basis of Comparison.

9.4.2.2 No Action Alternative

As described in Chapter 3, Description of Alternatives, the No Action Alternative includes implementation of the 2008 USFWS BO and the 2009 NMFS BO Reasonable and Prudent Alternative (RPA) actions. It also includes changes not related to the coordinated long-term operation of the CVP and SWP, specifically changes in CVP and SWP operations caused by climate change and sea level rise, increased CVP and water rights water demand in portions of the Sacramento Valley, and implementation of reasonable and foreseeable non-CVP or SWP water resources management projects to provide water supplies. The resulting changes in ecological attributes and subsequent effects on fish and aquatic resources would vary geographically, as described below.

As described in Chapter 5, Surface Water Resources and Water Supplies, 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. By 2030, the reservoirs would be full more frequently by the end of April or May 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 storage in fall (end of September storage) 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. Sea level rise also would result in reduced CVP and SWP reservoir storage because the CVP and SWP must continue to meet the salinity criteria to protect Delta water users and Delta aquatic resources, including the SWRCB D-1641 and other salinity criteria to protect Delta water users. To meet these criteria, the amount of water released from CVP and SWP reservoirs must be increased as compared to recent historical conditions.

9.4.2.2.1 Trinity River Region

Aquatic Habitat Conditions in CVP and SWP Reservoirs

As described in Chapter 5, Surface Water Resources and Water Supplies, end of September reservoir storage in Trinity Lake would be lower by 2030 as compared to recent historical conditions due to climate change and related lower snowfall. Lewiston Reservoir, a regulating reservoir, would be operated with daily changes similar to historical conditions. These changes are not anticipated to substantially affect aquatic resources in Trinity Lake or Lewiston Reservoir relative to recent historical conditions.

Aquatic Habitat Conditions in Trinity and Lower Klamath Rivers

Under the No Action Alternative, flow, water temperature, and aquatic habitat conditions in the Trinity River would continue to be influenced by CVP and SWP operations as described in the Affected Environment. Due to the increased potential for reduced Trinity Lake surface water storage (see above), there could be an increased potential for reduced Trinity River flows during the summer and fall months under the No Action Alternative as compared to recent historical conditions. The influence of climate change could result in higher water temperatures in Trinity Lake that could translate to higher release temperatures in the flow releases from Lewiston Dam and a reduction in habitat quality within the Trinity River for salmonids and other native species.

By 2030, implementation of 2009 NMFS BO RPA Action II.6, Preparation of Hatchery Genetic Management Plans for spring- and fall-run Chinook Salmon at the Trinity River Fish Hatchery, which is not currently being implemented, could reduce the adverse influence of recent hatchery operations on naturally produced fall-run and spring-run Chinook Salmon, and increase genetic diversity and diversity of run timing for these stocks.

Effects Related to Water Transfers

It is not anticipated that water would be transferred to or from the Trinity River Region. It also not anticipated that water transfers would result in changes to Trinity Lake operations. Therefore, there would be no change in aquatic habitat conditions as a result of water transfers.

9.4.2.2.2 Central Valley Region

Aquatic Habitat Conditions in CVP and SWP Reservoirs

Seasonal changes in reservoir surface elevations, storage volumes, and the volume of cold water held within the reservoirs would continue under the No Action Alternative. Conditions for reservoir fishes would continue to change seasonally in response to inflow and downstream flow releases to meet demand. Recent historical averages for reservoir storage and surface elevations in Shasta Lake, Lake Oroville, and Folsom Lake generally show increases in March and April, with a reduction in storage occurring in many years during May and June in response to releases to meet downstream demands. Water surface elevations in New Melones Reservoir generally decline throughout the spring period in many years, with reductions typically occurring from April through June.

As described in Chapter 5, Surface Water Resources and Water Supplies, end of September reservoir storage would be lower by 2030 as compared to recent historical conditions in Shasta Lake, Lake Oroville, Folsom Lake, New Melones Lake, and San Luis Reservoir due to climate change and related lower snowfall. Whiskeytown Lake, Keswick Reservoir, Thermalito Forebay and Afterbay, and Lake Natoma are regulating reservoirs and would be operated with daily changes similar to historical conditions.

Under the No Action Alternative, the magnitude of changes in seasonal surface elevation and reservoir storage could be more pronounced because of changes in the timing and intensity of storm events due to climate change and an overall reduction in snow pack. A smaller snowpack could result in less water entering the reservoirs during the spring months and an increased frequency of reservoir elevation declines during the spring months. By 2030, fish in these reservoirs that spawn in shallow water (e.g., various species of black bass) could be subject to a hydrologic regime that increases the frequency of reductions in surface elevation during the spring spawning period, reducing spawning success. In addition, reduced storage volumes and reduction of the cold water pools could reduce the amount and suitability of habitat for cold water fishes (e.g., trout) within the reservoirs relative to recent historical conditions.

Aquatic Habitat Conditions in Rivers Downstream of CVP and SWP Facilities

As described in Chapter 5, Surface Water Resources and Water Supplies, surface water flows are anticipated to increase during the winter months as a result of an increase in rainfall and decrease in snowfall, and to decrease in other months because of the diminished snowmelt flows in the spring and early summer months. In wetter years, fall flows may be increased relative to recent conditions to meet downstream targets for Fall X2, which would lead to reduced reservoir storage in the following months and less carryover storage in May of the following year.

As described in Chapter 6, Surface Water Quality, climate change is anticipated to result in higher water temperatures during portions of the year, with a corresponding reduction in habitat quality for salmonids and other cold water fishes. Increased downstream water demands and climate change are anticipated to contribute to an inability to maintain an adequate cold water pool in critical dry years and extended dry periods in the future.

Implementation of the 2008 USFWS BO and the 2009 NMFS BO Reasonable and Prudent Alternative (RPA) actions under the No Action Alternative are anticipated to benefit aquatic species. The resulting changes in ecological attributes and subsequent effects on fish and aquatic resources would vary from river to river, as described below.

Aquatic Habitat Conditions in the Clear Creek from Whiskeytown Dam to Sacramento River

Under the No Action Alternative, flow, water temperature, and aquatic habitat conditions in Clear Creek would continue to be influenced by CVP and SWP operations as described in the Affected Environment. Whiskeytown Reservoir would continue to be operated to convey water from the Trinity River to the Sacramento River via the Spring Creek tunnel and to release flows to Clear Creek to support anadromous fish.

The No Action Alternative includes a suite of six 2009 NMFS BO RPA actions, intended to improve conditions for salmonids. These actions individually or in combination could influence conditions in Clear Creek by 2030. These include:

- 2009 NMFS BO RPA Action I.1. Spring Attraction Flows
- 2009 NMFS BO RPA Action I.2. Channel Maintenance Flows
- 2009 NMFS BO RPA Action I.3. Spawning Gravel Augmentation
- 2009 NMFS BO RPA Action I.4. Spring Creek Temperature Control Curtain
- 2009 NMFS BO RPA Action I.5. Thermal Stress Reduction
- 2009 NMFS BO RPA Action I.6. Adaptively Manage to Habitat Suitability/IFIM Study Results

Two of the actions involve additional flow releases to Clear Creek. 2009 NMFS BO RPA Action I.1, requires at least two pulse flows in May and June to attract adult spring-run Chinook Salmon holding in the Sacramento River. The pulse flows would be continued annually, and are expected to improve conditions for spring-run Chinook Salmon into the future. In addition, 2009 NMFS BO RPA Action I.1.2, requires the release of channel maintenance flows of a minimum of 3,250 cfs into Clear Creek seven times in a ten-year period. These channel maintenance flows are intended to provide the higher flows necessary to move spawning gravels downstream from injection sites (locations where gravel augmentation is implemented) for the purpose of increasing the amount of spawning habitat available to spring-run Chinook Salmon and steelhead. However, as described in Chapter 5, Surface Water Resources and Water Supplies, the feasibility of releasing these flows is influenced by dam safety considerations and operational constraints, and the delivery of flows of this frequency may not be possible, thus the movement of gravel through mechanical means may be required to achieve this objective.

2009 NMFS BO RPA Action I.1.3 addresses the limited availability of spawning habitat in Clear Creek through the placement of gravel in selected sites in the creek. This program is expected to continue under the No Action Alternative, with ongoing improvements to spawning habitat for steelhead, and spring-run and fall-run Chinook Salmon.

Water temperatures in Clear Creek are influenced by the temperature of water in the Whiskeytown Reservoir and, to some extent, the magnitude of the release flows. As described in the Affected Environment, Reclamation has managed releases since 2002 to meet a daily average water temperature target of 56°F at the Igo Gauge (4 miles downstream of Whiskeytown Dam) from September 15 through October 30 to support spring-run Chinook Salmon spawning. Beginning in 2004, an additional daily average temperature target of 60°F was implemented from June 1 to September 15 to protect over-summering juvenile steelhead and holding adult spring-run Chinook Salmon. 2009 NMFS BO RPA Action I.1.5 continues these temperature targets; however, recent real time operations have experienced difficulty in meeting the temperature objectives, and by 2030, it may not be possible to meet the temperature targets as often. The Spring Creek Temperature Control Curtain in Whiskeytown Lake repaired in 2011 (and also included in the 2009 NMFS BO RPA) improves this condition by retaining cold water that is released to reduce water temperatures during the summer for over-summering juvenile steelhead and holding adult spring-run Chinook Salmon and during the fall for spring- and winter-run Chinook Salmon spawning and incubation.

2009 NMFS BO RPA Action I.1.6 requires adaptive management of flows in Clear Creek based on results of habitat suitability/IFIM studies. If warranted by the studies and if sufficient water is available, this action could result in modified minimum flows in Clear Creek during the fall and winter to improve conditions for spawning and incubating salmonids. Whether flow requirements would be modified by 2030 and the extent of any changes are currently unknown.

Aquatic Habitat Conditions in the Sacramento River from Keswick to Freeport

Under the No Action Alternative, flow, water temperature, and aquatic habitat conditions in the Sacramento River downstream of Keswick Dam would continue to be influenced by CVP and SWP operations as described in the Affected Environment. Shasta Lake would continue to be operated to convey water from the Sacramento River to the Delta and release flows to the Sacramento River to support anadromous fish.

The No Action Alternative includes a variety of 2009 NMFS BO RPA actions or action suites intended to improve conditions for salmonids. These actions individually or in combination could influence conditions in the Sacramento River (and Battle Creek) by 2030. These include:

- 2009 NMFS BO RPA Action Suite I.2.1. Shasta Operations
  - 2009 NMFS BO RPA Action Suite I.2.1. Performance Measures

  - 2009 NMFS BO RPA Action I.2.2 (including I.2.2.A–I.2.2.C). November through February Keswick Release Schedule (Fall Actions)
  - 2009 NMFS BO RPA Action I.2.3 (including I.2.3.A–I.2.3.C). February Forecast; March – May 14 Keswick Release Schedule (Spring Actions)
  - 2009 NMFS BO RPA Action I.2.4. May 15 Through October Keswick Release Schedule (Summer Action)
  - 2009 NMFS BO RPA Action I.2.5. Winter-Run Chinook Salmon Passage and Reintroduction Program at Shasta Dam – See "Conditions for Fish Passage"
  - 2009 NMFS BO RPA Action I.2.6. Restore Battle Creek for Winter-Run, Spring-Run, and CV Steelhead
- 2009 NMFS BO RPA Action Suite I.3. Red Bluff Diversion Dam (RBDD) Operations
- 2009 NMFS BO RPA Action I.4. Wilkins Slough Operations
- 2009 NMFS BO RPA Action I.5. Funding for CVPIA Anadromous Fish Screen Program

Action Suite I.2 (Shasta Operations) was aimed at maintaining suitable temperatures for egg incubation, fry emergence, and juvenile rearing in the Sacramento River for the survival and recovery of the winter-run Chinook Salmon ESU. Spring-run Chinook Salmon and steelhead are also affected by temperature management actions from Shasta Lake. This suite of actions is designed to ensure that Reclamation uses maximum discretion to reduce adverse impacts of the projects to Chinook Salmon and steelhead in the Sacramento River by maintaining sufficient carryover storage and optimizing use of the cold water pool. Because Reclamation already operates Shasta Lake to optimize use of the cold water pool and maintain carryover storage for temperature control in the Sacramento River downstream of Shasta and Keswick dams, implementation of this suite of actions would have little effect on habitat conditions for winter-run Chinook Salmon and other fish species in the Sacramento River under the No Action Alternative.

A temperature control device has been in operation at Shasta Dam since 1998, with operations capable of maintaining a water temperature of 56°F downstream to Balls Ferry Bridge in most years through the summer spawning period for winter-run. Under the No Action Alternative, the ability to control water temperatures depends on a number of factors and management flexibility usually ends in October when the cold water pool in Shasta Lake is depleted. With climate change, cold water storage at the end of May in Shasta Lake is expected to be reduced under the No Action Alternative for all water year types. This would further reduce the already limited cold water pool in late summer. With the anticipated increase in demands for water by 2030 and less water being diverted from the Trinity River, it is expected that it would become increasingly difficult to meet water temperature targets at the various temperature compliance points.

It is likely that severe temperature-related effects will be unavoidable in some years under the No Action Alternative. Due to these unavoidable adverse effects, RPA Action Suite I.2 also specifies other actions that Reclamation must take, within its existing authority and discretion, to compensate for these periods of unavoidably high temperatures. These actions include restoration of habitat at Battle Creek (see below) which may support a second population of winter-run Chinook Salmon, and a fish passage program at Keswick and Shasta dams to partially restore winter-run Chinook Salmon to their historical cold water habitat.

2009 NMFS BO RPA Action Suite I.3 addresses mortality and delay of adult and juvenile migration of winter-run, spring-run, steelhead, and green sturgeon caused by the presence of the RBDD and the configuration of the operable gates. As described in the Affected Environment, the Red Bluff Pumping Plant and fish screen, which diverts water to the Tehama Colusa Canal and Corning Canal, was constructed to allow year-round opening of the gates at the RBDD, and is included in the 2009 NMFS BO as Action Suite I.3. Allowing the dam gates at RBDD to remain open allows salmonids, sturgeon, and other fish species to pass unimpeded all year. These passage improvements are completed and are anticipated to benefit fish species that migrate upstream of the RBDD location through improved access to spawning and rearing areas and a reduction in predation due to dispersal of predator species like Striped Bass and Sacramento Pikeminnow.

Implementation of 2009 NMFS BO RPA Action I.4 is anticipated to enhance the ability to manage temperatures for anadromous fish downstream of Shasta Dam through adjusting Wilkins Slough flow criteria in a manner that best conserves the cold water pool for summer releases. In years other than critical dry years, the need for a variance from the 5,000 cfs navigation criterion will be considered during the process of developing the Keswick release schedules (Action I.2.2-4). Reclamation has stated that it is no longer necessary to maintain 5,000 cfs at Wilkins Slough for navigation (CVP/SWP operations BA, page 2-39), however, the 5,000 cfs flow criterion is now used to support long-time water diversions that have set their intake pumps just below this level. Under the No Action Alternative, operating to a minimal flow level at Wilkins Slough based on fish needs, rather than on outdated navigational requirements, could enhance the ability to use cold water releases to maintain cooler summer temperatures in the Sacramento River.

The No Action Alternative includes implementation of the CVPIA AFSP to reduce entrainment of juvenile anadromous fish from unscreened diversions. This program is also addressed in the 2009 NMFS BO RPA Action I.5. By providing funding to screen priority diversions as identified in the CVPIA AFSP, the loss of listed fish in water diversion channels by 2030 could be reduced. In addition, if new fish screens can be constructed so that diversions can occur at low water surface elevations to allow diversions below a flow of 5,000 cfs at Wilkins Slough, then cold water at Shasta Lake could be conserved during critical dry years for release to support winter-run and spring-run Chinook Salmon needs downstream.

As described in the Affected Environment, implementation of the Battle Creek Restoration Program is underway in accordance with implementation of the CVPIA. This action, also included in the 2009 NMFS BO RPA Action I.2.6, is being implemented to partially compensate for unavoidable adverse effects of project operations by restoring winter-run and spring-run Chinook Salmon to the Battle Creek watershed. Full implementation of the Battle Creek Restoration Program under the No Action Alternative would substantially improve passage conditions for adult Chinook Salmon and steelhead by 2030 and would result in newly accessible anadromous fish habitat and improved water quality for the Coleman National Fish Hatchery (Reclamation and SWRCB 2003). Implementation of the RPA helps ensures that the Battle Creek experimental winter-run Chinook Salmon re-introduction program will proceed in a timely fashion. The Battle Creek Restoration Program is critical in creating a second population of winter-run Chinook Salmon. A second population of winter-run Chinook Salmon would reduce the risk that lost resiliency and increased vulnerability to catastrophic events might result in extinction of the species.

Aquatic Habitat Conditions in the Feather River from Oroville Dam to Sacramento River

As described in Chapter 5, Surface Water Resources and Water Supplies, and Chapter 6, Surface Water Quality, the NMFS and 2008 USFWS BO RPAs did not specifically recommend actions for Feather River operations. However, Reclamation and DWR operate the Shasta-Oroville-Folsom coordinated releases pursuant to 2009 NMFS BO RPA Actions 1.2.2C and 1.2.3B. The following two RPA actions for operations in the Sacramento River influence Feather River operations required to meet Delta outflow, X2, or other legal requirements:

- Action I.2.2. (including I.2.2.A–I.2.2.C) November through February Keswick Release Schedule (Fall Actions)
- Action I.2.3. (including I.2.3.A–I.2.3.C) February Forecast; March – May 14 Keswick Release Schedule (Spring Actions).

Under the No Action Alternative, Feather River flows in the high flow channel downstream of Thermalito Dam would be influenced by releases for Fall X2 Delta outflow requirements, regulation to meet water temperature criteria, and to time Lake Oroville releases and Delta export operations as described for the Affected Environment. Flows in the low flow channel downstream of Lake Oroville would remain similar to recent conditions. As part of the ongoing FERC relicensing process for the Oroville facilities, DWR has entered into a Settlement Agreement (DWR 2006) that includes actions to be implemented and included as terms of the anticipated FERC license. Depending on the progress of the relicensing process, these actions could be implemented by 2030 and would change fish habitat conditions in the Feather River relative to recent conditions.

Under the terms of the Settlement Agreement, DWR will develop a comprehensive Lower Feather River Habitat Improvement Plan. The Plan will provide an overall strategy for managing the various environmental measures developed for implementation in the plan area. The following programs and plans will be included in the comprehensive Lower Feather River Habitat Improvement Plan:

1) Gravel Supplementation and Improvement Program
2) Channel Improvement Program
3) Structural Habitat Supplementation and Improvement Program
4) Fish Weir Program
5) Riparian and Floodplain Improvement Program including the evaluation of pulse/flood flows
6) Feather River Fish Hatchery Improvement Program
7) Comprehensive Water Quality Monitoring Program
8) Oroville Wildlife Area Management Plan
9) Instream Flow and Temperature Improvement for Anadromous Fish.

Implementation of these programs and plans under the terms of the Settlement Agreement as incorporated into the new license are anticipated to improve habitat conditions and water quality for salmonids and other fishes using the channels of the Feather River above the confluence with the Sacramento River.

Aquatic Habitat Conditions in the American River from Nimbus Dam to Sacramento River

As described in the Affected Environment section, Reclamation releases water to the lower American River consistent with flood control requirements; existing water rights; CVP operations; the Lower American River Flow Management Standard flow recommendations developed by Reclamation, the Sacramento Area Water Forum, USFWS, NMFS, DFW, and other interested parties; SWRCB Decision 893 (D-893); and requirements of the 2009 NMFS BO RPA. The following two RPA actions for operations in the Sacramento River influence American River operations required to meet Delta outflow, X2, or other legal requirements:

- Action I.2.2. (including I.2.2.A–I.2.2.C) November through February Keswick Release Schedule (Fall Actions)
- Action I.2.3. (including I.2.3.A–I.2.3.C) February Forecast; March – May 14 Keswick Release Schedule (Spring Actions).

The No Action Alternative includes a variety of 2009 NMFS BO RPA actions or action suites intended to improve conditions for salmonids in the lower American River. These actions individually or in combination could influence conditions in the American River by 2030. These include:

- 2009 NMFS BO RPA Action II.2.1. Lower American River Flow Management
- 2009 NMFS BO RPA Action II.2. Lower American River Temperature Management
- 2009 NMFS BO RPA Action II.3. Structural Improvements
- 2009 NMFS BO RPA Action II.4. Minimize Flow Fluctuation Effects
- 2009 NMFS BO RPA Action II.5. Fish Passage at Nimbus and Folsom dams
- 2009 NMFS BO RPA Action II.6.1. Preparation of Hatchery Genetic Management Plan (HGMP) for Steelhead
- 2009 NMFS BO RPA Action II.6.2. Interim Actions Prior to Submittal of Draft HGMP for Steelhead.

Under the No Action Alternative, American River flows would be influenced by releases for Fall X2 Delta outflow requirements, regulation to meet water temperature criteria, and to time Folsom Dam releases and Delta exports. However, by 2030, increasing water demands and the influence of climate change could worsen conditions for fish in the lower American River, particularly for salmonids.

Reclamation releases water from Folsom Lake to implement the flow schedule specified in the American River Flow Management Standard. The flow schedule was developed and implemented prior to issuance of the 2009 NMFS BO (Action II.1) to establish required minimum flows for anadromous salmonids in the lower American River. The flow schedule specifies minimum flows and does not preclude Reclamation from making higher releases at Nimbus Dam. The flow schedule was developed to require more protective minimum flows in the lower American River in consideration of the river’s aquatic resources, particularly steelhead and fall-run.

Reclamation manages the Folsom/Nimbus Dam complex and the water temperature control shutters at Folsom Dam to maintain a daily average water temperature of 65°F or lower at Watt Avenue Bridge from May 15 through October 31, to provide suitable conditions for juvenile steelhead rearing in the lower American River. Water temperature is the physical factor with the greatest influence on salmonids in the American River. The inability to maintain suitable water temperatures for all life history stages of steelhead in the American River is a chronic issue because of operational (e.g., Folsom Lake operations to meet Delta water quality objectives and demands and deliveries to M&I users in Placer, El Dorado, and Sacramento County) and structural (e.g., limited reservoir water storage and cold water pool) factors. Under the No Action Alternative, increased water demand and climate change are expected to lead to further reductions in suitable habitat conditions and increased water temperatures.

2009 NMFS BO RPA Action II.3 requires Reclamation to evaluate physical and structural modifications that may improve temperature management capability in the lower American River. Structural improvements to be further evaluated and potentially implemented include: improvements to the Folsom Dam TCD, cold water transport through Lake Natoma, installation of a TCD at El Dorado Irrigation District's intake or its functional equivalent, and improved temperature management decision-support tools. If one or more of these actions are implemented by 2030, they could increase the likelihood that water temperatures would be suitable for steelhead more frequently.

2009 NMFS BO RPA Action II.4 addresses stranding and isolation of juvenile steelhead through implementation of flow ramping protocols. Implementation of this action, including the continued monitoring for stranding and isolation of salmonids in conjunction with flow fluctuations under the No Action Alternative, could help to better predict the potential for steelhead redd dewatering and isolation, fry stranding, and fry and juvenile isolation and to potentially avoid adverse effects to salmonids.

As described above, temperature-related effects are likely during some years under the No Action Alternative. Because of these unavoidable effects, RPA Action II.5 requires Reclamation to evaluate options for providing steelhead access their historic cold water habitat above Nimbus and Folsom dams and to provide access if feasible.

Under the No Action Alternative, 2009 NMFS BO RPA Action Suite II.6, which addresses project effects related to the Nimbus Fish Hatchery related to introgression of out-of-basin hatchery stock with wild steelhead populations in the Central Valley, would be implemented. Implementation of an HGMP prior to 2030 should minimize the effects of the ongoing steelhead hatchery program on the Central Valley steelhead DPS.

Implementation of the HGMP also would reduce operational effects on Killer Whale prey over the long term by improving the genetic diversity and diversity of run timing of Central Valley fall-run Chinook Salmon, decreasing the potential for localized prey depletions and increasing the likelihood that fall-run Chinook Salmon could withstand stochastic events, such as poor ocean conditions. By 2030, implementation of this action could begin to contribute to a more consistent food source for Killer Whales, even in years with overall poor Chinook Salmon productivity.

Aquatic Habitat Conditions in the San Joaquin River from Friant Dam to the Stanislaus River

Under the No Action Alternative, operations at Friant Dam would remain similar to those described under the Affected Environment. Therefore, fish and aquatic habitat conditions in the San Joaquin River downstream of Friant Dam would remain similar to those described under the Affected Environment, although water temperatures could increase as a result climate change.

Aquatic Habitat Conditions in the Stanislaus River from Goodwin Dam to San Joaquin River

Under the No Action Alternative, flow, water temperature, and aquatic habitat conditions in the Stanislaus River downstream of Goodwin Dam would continue to be influenced by CVP operations as described in Chapter 5, Surface Water Resources and Water Supplies. Flows in the lower Stanislaus River are primarily controlled by releases from New Melones Lake. Water released from New Melones Dam and Powerplant is re-regulated at Tulloch Reservoir and is either diverted at Goodwin Dam or released from Goodwin Dam to the lower Stanislaus River.

The No Action Alternative includes a variety of 2009 NMFS BO RPA actions or action suites intended to improve conditions for salmonids in the Stanislaus River. These actions individually or in combination could influence conditions in the Stanislaus River by 2030. These include:

- 2009 NMFS BO RPA Action III.1.1. Establish Stanislaus Operations Group (SOG) for real-time operational decision-making
- 2009 NMFS BO RPA Action III.1.2. Provide cold water releases to maintain suitable steelhead temperatures
- 2009 NMFS BO RPA Action III.1.3. Operate the East Side Division dams to meet minimum flows
- 2009 NMFS BO RPA Action Suite III.2. Stanislaus River CV Steelhead Habitat Restoration
  - 2009 NMFS BO RPA Action III.2.1. Increase and improve quality of spawning habitat with addition of gravel
  - 2009 NMFS BO RPA Action III.2.2. Conduct floodplain restoration and inundation flows in winter or spring to inundate steelhead juvenile rearing habitat
  - 2009 NMFS BO RPA Action III.2.3. Restore freshwater migratory habitat for juvenile steelhead
  - 2009 NMFS BO RPA Action III.2.4. Evaluate Fish Passage at New Melones, Tulloch, and Goodwin dams

Under the No Action Alternative, Stanislaus River flows would be influenced by regulations to meet water quality and flow criteria. However, by 2030, conditions for fish, particularly salmonids, in the Stanislaus River fish are expected to worsen because of increased temperatures due to the influence of climate change.

In accordance with 2009 NMFS BO RPA Action III.1.1, Reclamation has convened a Stanislaus Operations Group (SOG) to provide a forum for real-time operational flexibility implementation of the actions defined in the 2009 NMFS BO RPA. This group includes representatives from Reclamation, NMFS, USFWS, DWR, CDFW, SWRCB, and outside expertise at the discretion of NMFS and Reclamation. The SOG provides direction and oversight to ensure that the East Side Division actions are implemented, monitored for effectiveness and evaluated.

Under the No Action Alternative, Reclamation will continue, where feasible, to manage the cold water supply within New Melones Reservoir as described in 2009 NMFS BO RPA Action III.1.2. The objective of these temperature criteria is to provide suitable temperatures for Central Valley steelhead rearing, spawning, egg incubation, smoltification, and adult migration in the Stanislaus River downstream of Goodwin Dam. There are no temperature control devices at New Melones, Goodwin, or Tulloch dams; thus, temperature management flexibility is limited to storage and flow management under certain conditions. Access to resources to offset operational temperature effects on steelhead in the Stanislaus River will continue to be limited, particularly in Conference Years and in drier Mid-Allocation Years. Under the No Action Alternative, steelhead would continue to be vulnerable to elevated temperatures in dry and critical dry years, even if actions are taken to improve temperature management. The frequency of these occurrences is expected to increase with climate change-related temperature increases.

Under the No Action Alternative, Reclamation would continue to meet the minimum flow schedule, to the best of their ability, as described in 2009 NMFS BO RPA Action III.1.3. The objective of the minimum flow schedule is to maintain minimum base flows to provide habitat for all life history stages of steelhead and to incorporate habitat maintaining geomorphic flows in a flow pattern that would provide migratory cues to smolts and facilitate out-migrant smolt movement. The flow schedule specifies minimum flows and does not preclude higher releases for other operational criteria. However, due to limited availability of water under the CVP water rights, it would be difficult to fully implement this action. Therefore, habitat conditions for steelhead and other fish species in the Stanislaus River would be similar or reduced relative to recent conditions in the near term. The value of this habitat also may be adversely influenced by higher temperatures associated with climate change.

Ongoing implementation of 2009 NMFS BO RPA Action Suite III.2 through 2030 is anticipated to improve the physical habitat conditions for steelhead, although climate change may affect the types and cover rates of vegetation upslope of the river, and potentially increase the rate of fine sediment transport to the river and to spawning areas.

RPA Action III.2.4 requires Reclamation to evaluate options for providing steelhead access to their historic cold water habitat upstream of New Melones, Tulloch, and Goodwin dams and to provide access if feasible. As described above, temperature-related effects will be unavoidable in some years under the No Action Alternative. Lindley et al. (2007) identified the need for upstream habitat for salmonids, given predicted climate change in the next century. This may be particularly relevant for steelhead and salmon in the Stanislaus River where Goodwin Dam blocks all access to historical spawning and rearing habitat and where the remaining population survives as a result of dam operations in downstream reaches that were historically unsuitable habitat because of high summertime temperatures. To the extent that preliminary fish passage efforts are underway by 2030, this could improve conditions for Stanislaus River salmonids.

Aquatic Habitat Conditions in the Yolo Bypass (including Cache Slough, Lower Putah Creek, and Fremont Weir)

As described in Chapter 5, Surface Water Resources and Water Supplies, climate change would increase the frequency of high flow events that would result in flows into the Yolo Bypass by 2030 as compared to recent historical conditions. Implementation of the operable gates at the Fremont Weir also would increase the frequency of flows into the Yolo Bypass.

Under the No Action Alternative, it is assumed that aquatic habitat conditions in the Yolo Bypass would improve by 2030 as a result of the following 2009 NMFS BO RPA actions:

- 2009 NMFS BO RPA Action I.6.1. Restoration of Floodplain Rearing Habitat.
- 2009 NMFS BO RPA Action I.6.2. Near-Term Actions at Liberty Island/Lower Cache Slough and Lower Yolo Bypass.
- 2009 NMFS BO RPA Action I.6.3. Lower Putah Creek Enhancements.
- 2009 NMFS BO RPA Action I.6.4. Improvements to Lisbon Weir.
- 2009 NMFS BO RPA Action I.7. Reduce Migratory Delays and Loss of Salmon, Steelhead, and Sturgeon at Fremont Weir and Other Structures in the Yolo Bypass

Under the No Action Alternative, it is assumed that the elements of 2009 NMFS BO RPA Action Suite I.6.1 would be implemented in the Yolo Bypass, including up to 20,000 acres of shallow, low-velocity inundated floodplain. Actions in the Yolo Bypass also would include improvements in fish passage at Fremont Weir for anadromous salmonids, sturgeon, and other native fish species.

Passage at Fremont Weir would be facilitated by correcting a variety of passage issues within the bypass, including modification of agricultural structures in the northern Tule Canal that impede flow and cause fish passage delays. Modification of these structures under the No Action Alternative could substantially reduce fish passage delays through the Tule Canal. Similarly, replacement or modification of Lisbon Weir could allow unimpeded fish passage, reduced maintenance of the weir, and at the same time be managed to impound water for agriculture. In addition, the Knights Landing Ridge Cut could be modified to provide an exit path for upstream-migrating fish. These actions, along with the grading of downstream channels to improve connectivity to the Tule Canal when water levels fall as inundations recede and provide exit points for fish that would otherwise be stranded when inundations recede, are expected to improve conditions for salmonid rearing and fish passage by 2030.

Implementation of these ecosystem restoration actions and improvements under the No Action Alternative could increase growth and survival of juvenile Chinook Salmon, steelhead, and other native fish by providing increased seasonal access to productive foraging and high quality rearing habitat, depending on the extent and duration of restoration and inundation. These actions may also reduce migratory delays or losses by reducing predation, straying, and delays for salmonids and other migratory native fish species.

Aquatic Habitat Conditions in the Delta

Under the No Action Alternative, flows, water quality, and aquatic habitat conditions in the Delta would continue to be influenced by CVP and SWP operations as described in Chapter 5, Surface Water Resources and Water Supplies and Chapter 6, Surface Water Quality. Overall, long-term average CVP and SWP water supply deliveries in 2030 through the Delta would decline as compared to historical long-term average deliveries. Because entrainment of fish in the Delta export facilities is related to the amount of water exported, entrainment would decline relative to recent conditions as a result of reduced water supply delivery.

Under the No Action Alternative, climate change is anticipated to have more of an effect on Delta flows during wetter years than during drier years because CVP and SWP operations occur with more flexibility during wet years, within the constraints of flood control requirements, compared to drier years when the CVP and SWP operations may be more frequently constrained to maintain instream flows and other environmental objectives. Overall, it is anticipated that due to climate change, sea level rise, and increased water demands in the Sacramento Valley, there would be less CVP and SWP water available for export in the Delta and CVP and SWP exports would decline. The reduction in Delta exports would result in more positive OMR flows by 2030 as compared to recent historical conditions. In other words, it is expected that fish in the channels surrounding the CVP and SWP projects will be exposed to lower entrainment risks than under recent historical conditions as a result of changes in operation due to factors described above (i.e., climate change, sea level rise, and increased water demands in the Sacramento Valley) climate change by 2030.

The No Action Alternative includes a variety of RPA actions or action suites from both the USFWS and NMFS biological opinions intended to improve conditions in the Delta for Delta Smelt, Longfin Smelt, salmonids and sturgeon. These actions individually or in combination could influence aquatic habitat conditions in the Delta by 2030. These include:

- 2008 USFWS BO RPA Component 1 (Actions 1 and 2). Protection of the Adult Delta Smelt Life Stage.
- 2008 USFWS BO RPA Component 2 (Actions 3 and 5). Protection of Larval and Juvenile Delta Smelt.
- 2008 USFWS BO RPA Component 3 (Action 4). Improve Habitat for Delta Smelt Growth and Rearing (Fall X2).
- 2008 USFWS BO RPA Component 4 (Action 6). Habitat Restoration.

- 2009 NMFS BO RPA Action Suite IV.1. Modify DCC gate operations and evaluate methods to control access to Georgiana Slough and the Interior Delta to reduce diversion of listed fish from the Sacramento River into the southern or central Delta.
- 2009 NMFS BO RPA Action Suite IV.2. Control the net negative flows toward the export pumps in Old and Middle rivers to reduce the likelihood that fish will be diverted from the San Joaquin or Sacramento River into the southern or central Delta.
- 2009 NMFS BO RPA Action IV.3. Curtail exports when protected fish are observed near the export facilities to reduce mortality from entrainment and salvage.
- 2009 NMFS BO RPA Action Suite IV.4. Improve fish screening and salvage operations to reduce mortality from entrainment and salvage.

Component 1 of the 2008 USFWS BO RPA is designed to reduce entrainment of pre-spawning adult Delta Smelt during December to March by controlling OMR flows during vulnerable periods, including adaptive management of OMR flows based on input and guidance from the Smelt Working Group to further reduce entrainment. Action 1 is designed to protect upmigrating Delta Smelt and Action 2 is designed to protect adult Delta Smelt that have migrated upstream and are residing in the Delta prior to spawning. Overall, RPA Component 1 is expected to increase the suitability of spawning habitat for Delta Smelt by decreasing the amount of Delta habitat affected by export pumping prior to, and during, the critical spawning period.

Component 2 is intended to improve flow conditions in the Central and South Delta such that larval and juvenile Delta Smelt could successfully rear in the Central Delta and move downstream when appropriate. The spring HORB would be installed only if the USFWS determines Delta Smelt entrainment is not a concern.

Implementation of Component 3 of the 2008 USFWS BO RPA requires the provision of sufficient Delta outflow to maintain a monthly average X2 no greater than 74 km in Wet water year types and 81 km in Above Normal water years. The objective of this component is to improve fall habitat for Delta Smelt through increasing Delta outflow during fall. Increases in fall habitat quality and quantity are anticipated to improve conditions for Delta Smelt under the No Action Alternative. However, implementation of this action would result in reduced storage in upstream reservoirs which could adversely affect temperature management in the Sacramento, Feather, and American rivers.

Component 4 of the 2008 USFWS BO RPA is intended to improve conditions for Delta Smelt habitat to supplement the improvements resulting from the flow actions described above. DWR is required to implement a program to create or restore a minimum of 8,000 acres of intertidal and associated subtidal habitat in the Delta and Suisun Marsh. It is assumed under the No Action Alternative that this requirement would be met by the Suisun Marsh Restoration Program and would result in the restoration of more than 10,000 acres of intertidal and associated subtidal wetlands in Suisun Marsh and Cache Slough.

Implementation of the 2008 USFWS BO RPA would increase the likelihood that Delta Smelt habitat conditions and attributes for migration, spawning, recruitment, growth, and survival would be provided under the No Action Alternative. Implementation of actions under the 2008 USFWS BO RPA to restore tidally influenced habitat also is expected to increase salmonid and sturgeon rearing habitat and potentially food production for salmonids and Delta Smelt. Depending on the amount and type of restoration that would occur in brackish estuarine areas, restoration could increase rearing habitat for Sacramento Splittail, and alter conditions for predators and non-native fish species. Spawning habitat for roach, Hardhead, Sacramento Splittail, and Delta Smelt could be increased depending on whether restoration occurs in freshwater areas or in brackish estuarine areas. In addition, habitat restoration has the potential to alter habitat conditions for some invasive aquatic macrophyte species during some seasons, and in some locations, which could have indirect effects on predation.

Action Suite IV.1 of the 2009 NMFS BO RPA requires continued funding of monitoring programs at the RBDD, in spring-run Chinook Salmon tributaries to the Sacramento River, on the Sacramento River at Knights Landing and Sacramento, and sites within the Delta. In addition, salvage and loss of juvenile Chinook Salmon would be monitored at the Delta fish collection facilities operated by the CVP and SWP. A working group, composed of representatives from Reclamation, DWR, NMFS, USFWS, and CDFW, would develop and evaluate engineering solutions to reduce adverse impacts on listed fish and their critical habitat.

The DCC gate operations would be modified to reduce loss of emigrating salmonids and green sturgeon. The operating criteria provide for longer periods of gate closures during the outmigration season to reduce direct and indirect mortality of yearling spring-run and winter-run Chinook Salmon, and juvenile steelhead. Although route selection by Chinook Salmon and the mechanisms governing selection are complex (Perry et al. (2015), the closure of the DCC gates may increase the survival of salmonid emigrants through the Delta, and the early closures could reduce loss of fish with unique and valuable life history strategies in the spring-run Chinook Salmon and Central Valley steelhead populations.

Conditions under the No Action Alternative would be influenced by implementation of Action Suite IV.2 of the 2009 NMFS BO RPA. This action suite requires the maintenance of adequate flows in both the Sacramento River and San Joaquin River basins to increase survival of steelhead emigrating to the estuary from the San Joaquin River, and of Chinook Salmon, steelhead, and Green Sturgeon emigrating from the Sacramento River through the Delta to Chipps Island. This action suite includes actions to reduce the vulnerability of emigrating steelhead within the lower San Joaquin River to entrainment into the channels of the South Delta and at the export facilities by increasing the inflow to export ratio. Cunningham et al. (2015) found a negative influence of the export/inflow ratio on the survival of fall-run Chinook populations and a negative influence of increased total Delta exports on the survival of spring-run Chinook populations. In addition, there are actions to enhance the likelihood of salmonids successfully exiting the Delta at Chipps Island by creating more suitable hydraulic conditions in the main stem of the San Joaquin River for emigrating fish, including greater net downstream flows. Historical data suggest that high San Joaquin River flows in the spring result in higher survival of outmigrating Chinook Salmon smolts and greater returns of adults. The data also suggest that when the ratio between spring flows and exports increase, Chinook Salmon production increases. Increased flows within the San Joaquin River portion of the Delta could also enhance the survival of Sacramento River salmonids. Those fish from the Sacramento River that have been diverted through the interior Delta to the San Joaquin River could benefit by the increased net flow towards the ocean caused by the higher flows in the San Joaquin River from upstream and the reduced influence of the export pumps.

2009 NMFS BO RPA Action Suite IV.2 also includes flow management for the Old and Middle rivers that would be implemented in conjunction with the restrictions on exports under the 2008 USFWS BO RPA. Old and Middle river flow management is designed to ensure that emigrating steelhead from the San Joaquin Basin and the east-side tributaries remain in the mainstem of the San Joaquin River to the greatest extent possible and reduce their exposure to the adverse effects that are present in the channels leading south toward the export facilities. This is anticipated to increase the likelihood of survival of steelhead emigrating from the San Joaquin River. Reducing the risk of diversion into the central and southern Delta waterways also could increase survival of listed salmonids and Green Sturgeon entering the San Joaquin River via Georgiana Slough and the lower Mokelumne River. However, recent coded wire tagging and acoustic studies have shown survival to be reach specific for both Chinook Salmon and steelhead and that survival of hatchery-origin (Feather River) juvenile Chinook Salmon was higher through the south Delta via the Old River route than via the San Joaquin River (Buchanan et al. 2013, 2015). However, most fish in the Old River that survived to the end of the Delta had been salvaged from the federal water export facility on the Old River and trucked around the remainder of the Delta (Buchanan et al. 2013, SJRGA 2013). Zeug and Cavallo (2014) suggest that entrainment losses at the diversions may be small relative to overall migration mortality.

The 2009 NMFS BO RPA Action IV.3 requires operations of the Tracy and Skinner Fish Collection Facilities to be modified according to monitoring data from upstream of the Delta. In conjunction with the two alerts for closure of the DCC (Action IV.1.1), a third alert would be used to signal that export operations may need to be altered due to large numbers of juvenile Chinook Salmon migrating into the upper Delta region, increasing their risk of entrainment into the central and south Delta and then to the export pumps. When more fish are present, more fish are at risk of diversion and losses would be higher. The third alert is important for real-time operation of the export facilities because the collection and dissemination of field data to the resource agencies and coordination of response actions could take several days. This action is designed to work in concert with the Old and Middle River flow management in action suite IV.2. Under the No Action Alternative, implementation of this action is anticipated to reduce losses of winter-run and spring-run Chinook Salmon, steelhead, and Green Sturgeon by reducing exports when large numbers of juvenile Chinook Salmon are migrating into the upper Delta region.

Action Suite IV.4 of the 2009 NMFS BO RPA is designed to increase the efficiency of the Tracy and Skinner Fish Collection Facilities to improve the overall salvage survival of winter-run and spring-run Chinook Salmon, steelhead, and Green Sturgeon to achieve a 75 percent performance goal for whole facility salvage at both state and Federal facilities. Reclamation and DWR will (1) conduct studies to evaluate current operations and salvage criteria to reduce take associated with salvage, (2) develop new procedures and modifications to improve the current operations, and (3) implement changes to the physical infrastructure of the facilities where information indicates such changes need to be made. In addition, Reclamation would continue to fund and implement the CVPIA Tracy Fish Facility Program. Reclamation and DWR would fund quality control and quality assurance programs, genetic analysis, louver cleaning loss studies, release site studies and predation studies. Funding would also be provided for new studies to estimate Green Sturgeon screening efficiency at both facilities and survival through the trucking and handling process. Under the No Action Alternative, implementation of measures to fund fish screens, reduce pre-screen loss, improve screening efficiency, and improve reporting could reduce entrainment and salvage, and result in improved survival for juvenile Salmonids migrating downstream through the Delta, as well as for Sacramento Splittail, Delta Smelt, and other native fish species.

Abundance and habitat conditions for Delta Smelt and other fish species in the Delta under the No Action Alternative in 2030 are difficult to predict. Abundance levels for Delta Smelt, Longfin Smelt, Striped Bass, Threadfin Shad, and American Shad under recent conditions are very low compared to pre-POD levels, as evidenced by the number of fish collected in sampling programs such as the FMWT surveys conducted by the IEP. Numbers of fish collected have continued to decline in recent years, even with implementation of the RPAs. Annual reviews conducted by the Delta Science Program Independent Review Panel (IRP) for the Long-Term Operations Biological Opinions have called for better metrics to measure the effects of the BO RPAs on the protected species (IRP 2011, 2013, 2014) to allow more informed decision-making, while acknowledging challenges, constraints, and the complexity of the issues.

Currently low levels of relative abundance do not bode well for the Delta Smelt or other fish species in the Delta in 2030. Challenges to fish species in the Delta are many, and would continue in the future under the No Action Alternative, including high water temperatures, reduced flows, habitat degradation, barriers, predation, low DO, contamination, entrainment, salvage, poaching, disease, competition, non-native species, and lack of available food. Use of observations on current conditions to predict future long-term changes for Delta fish is especially challenging when combined with other potentially adverse future changes foreseen for the Delta, e.g., altered hydrology due to drought, rising temperatures, and potential sea level rise (Sommer and Meija, 2013).

9.4.2.2.3 Special Status Species and Critical Habitat

Clear Creek

Clear Creek is designated critical habitat for spring-run Chinook Salmon and Central Valley steelhead. The Primary Constituent Element (PCEs) of critical habitat for both species include freshwater spawning sites, freshwater rearing areas, and freshwater migration corridors. Spawning and rearing habitat for spring-run Chinook Salmon in Clear Creek has been negatively affected by flow and water temperature conditions associated with current operations. As described above, it is anticipated minimum flows in Clear Creek would be increased during the fall and winter to improve conditions for spawning salmonids as a result of recently completed IFIM studies. Continuation of spring pulse flows (RPA Action I.1.1) and implementation of channel maintenance flows (RPA Action I.1.2), in conjunction with ongoing gravel augmentation in Clear Creek, is expected to result in improvements in the PCEs of critical habitat for spring-run Chinook Salmon and steelhead relative to recent conditions.

Sacramento River

The Sacramento River provides three of the six PCEs essential to support one or more life stages, including freshwater spawning sites, rearing sites, and migration corridors for winter-run and spring-run Chinook Salmon and steelhead. The Sacramento River is also designated critical habitat for the Southern DPS of Green Sturgeon. Flow and temperature changes under the No Action Alternative and the effects on spawning and rearing habitat quality were described previously.

Climate change is likely to reduce the conservation value of the spawning habitat PCE of critical habitat by increasing water temperatures, which would reduce the availability of suitable spawning habitat. Cold water in Shasta Lake is expected to be depleted sooner in the summer, impacting winter-run and spring-run Chinook Salmon spawning habitat. This reduction in an essential feature of the spawning habitat PCE could reduce the spatial structure, abundance, and productivity of salmonids. Similarly, as described above, climate change is likely to reduce availability of rearing habitat, and in turn, the value of the rearing habitat PCE of critical habitat, by increasing water temperatures.

The year-round opening of the gates at the RBDD in accordance with Action Suite I.3 of the 2009 NMFS BO RPA allows salmonids to pass unimpeded, enhancing the conservation value of the PCE for migration. Critical habitat for Green Sturgeon would also improve from unimpeded access to suitable spawning habitat upstream of the RBDD. The improved passage at the RBDD location is expected to increase the number of deep holding pools that adult Green Sturgeon can access, thereby increasing the conservation value of the water depth PCE. In addition, predation on salmon, steelhead, and sturgeon would be reduced relative to conditions when the RBDD was operational.

American River

The lower American River downstream of Nimbus Dam is designated critical habitat for Central Valley steelhead. The PCEs of critical habitat in the lower American River include freshwater spawning sites, freshwater rearing areas, and freshwater migration corridors. Flow and temperature changes under the No Action Alternative and the effects on spawning and rearing habitat quality were described previously. In addition, the influence of climate change is expected to alter hydrologic and temperature conditions in the region and could adversely affect the PCEs for Central Valley steelhead critical habitat in the American River, primarily through increased water temperatures.

Stanislaus River

The lower Stanislaus River downstream of Goodwin Dam is designated critical habitat for Central Valley steelhead. The PCEs of critical habitat in the Stanislaus River include freshwater spawning sites, freshwater rearing areas, and freshwater migration corridors. Flow and temperature changes under the No Action Alternative and the effects on spawning and rearing habitat quality were described previously. The PCEs for spawning and rearing habitat have been adversely affected by elimination of geomorphic processes that replenish and rejuvenate spawning riffles and inundate floodplain terraces to provide nutrients and rearing habitat for juvenile salmonids. In addition, moderation of flood events also eliminates or reduces the intensity and duration of freshets and storm flows, which adversely affects the PCE for migration corridors. The influence of climate change could begin to alter hydrologic and temperature conditions in the region and adversely affect the PCEs for Central Valley steelhead critical habitat in the Stanislaus River, primarily through increased water temperatures.

Delta

Critical habitat for both winter-run and spring-run Chinook Salmon is designated in the Sacramento River adjacent to the location of the DCC gates. The DCC is specifically not included in designated critical habitat for winter-run Chinook Salmon because the biological opinions issued by NMFS in 1992 and 1993 included measures on the operations of the gates that were designed to exclude winter-run Chinook Salmon from the channel and the waters of the Central Delta. However, for spring-run Chinook Salmon, designated critical habitat does include the DCC from its point of origin on the Sacramento River to its terminus at Snodgrass Slough, including the location of the gates. Designated critical habitat for Central Valley steelhead includes most of the Delta and its waterways, but not the DCC waterway.

Operation of the DCC gates affects the PCEs for critical habitat designated for these species. Primarily, DCC gate operations interfere with the use of the Sacramento River as a migratory corridor for Chinook Salmon and steelhead juveniles during their downstream migration from spawning grounds upstream of the Delta to San Francisco Bay and the Pacific Ocean. The operation of the gates permits fish to enter habitat and waterways they would not normally access, with substantially higher predation risks than the migratory corridor available in the Sacramento River channel. Under the No Action Alternative, operation of the gates could have a direct effect on the entrainment rate and hence the functioning of the Sacramento River as a migratory corridor.

9.4.2.2.4 Effects Related to Cross Delta Water Transfers

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 associated with changes in reservoir storage and river flow patterns. Potential effects to aquatic 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 2014d). Potential effects were identified as changes to fish in the reservoirs and in the rivers downstream of the reservoirs and the Delta. The analysis indicated that the reservoirs did not support primary populations of fish species of management concern, and that the reservoirs would continue to be operated within the historical range of operations. The analysis also indicated that mean monthly flows in the major rivers or creeks in the Sacramento and San Joaquin rivers watersheds would be similar (less than 10 percent change) with water transfers as compared to without water transfers; and therefore, changes to aquatic resources would be less than substantial. Delta conditions also would be similar with water transfers as compared to without water transfers, including less than 5 percent changes in Delta exports and less than 1.3 percent changes in Delta outflow and X2 position. Therefore, changes to aquatic resources would be less than substantial. For the purposes of this EIS, it is anticipated that similar conditions would occur due to cross Delta water transfers under the No Action Alternative and the Second Basis of Comparison.

Under the No Action Alternative, the timing of cross Delta water transfers would be limited to July through September in accordance with the 2008 USFWS BO and 2009 NMFS BO. The maximum amount of water to be transferred would be 600,000 acre-feet/year in critical dry years or in dry years following a dry or critical dry year. In all other water year types, the maximum amount of water would be 360,000 acre-feet/year.

9.4.2.2.5 Conditions for Fish Passage

As described in Chapter 3, Description of Alternatives, the No Action Alternative includes a suite of RPA actions intended to examine the reintroduction of salmonids into historical habitats upstream of currently impassable artificial barriers. The actions include consideration for passage of winter-run and spring-run Chinook Salmon, and steelhead above Shasta Dam on the Sacramento River, steelhead above Nimbus and Folsom dams on the American River, and steelhead above Goodwin, Tulloch, and New Melones dams on the Stanislaus River. The action suite outlines multiple planning and implementation steps to evaluate the efficacy of passage before long-term fish passage is provided. However, for the purposes of the describing the No Action Alternative, fish passage at each of these facilities (likely through interim means) is assumed to be functional by 2030.

As described in the Affected Environment, Reclamation is currently developing near-term and long-term fish passage solutions to provide access by anadromous salmonids to habitat upstream of Shasta Lake (2009 NMFS BO RPA Action I.2.5). The evaluation includes assessments of amount, suitability, and location of potential habitat, potential risks (e.g., predation by resident fish, disease transmission), as well as feasibility of providing upstream and downstream passage. There are approximately 60 mainstem miles and the McCloud River upstream of Shasta Lake. Reclamation (2014c) estimated approximately 9 river-miles of suitable winter-run Chinook Salmon spawning habitat in the upper Sacramento River below Box Canyon Dam, and approximately 12 river-miles of suitable spawning habitat for winter-run Chinook Salmon in the McCloud River below McCloud Dam. By 2030, access to this habitat could not only expand the amount of habitat available for winter-run Chinook Salmon relative to recent conditions, but provide access to areas of temperature refuge at a time when water temperatures in the river downstream of Keswick Dam are anticipated to increase. This could be particularly beneficial as winter-run Chinook Salmon are currently at high risk of extinction. Extinction factors include: winter-run Chinook Salmon is composed of only one population, which has been blocked from all of its historic spawning habitat; the potential for catastrophic risks associated with proximity to Mt. Lassen and the population's dependency on the cold water management of Shasta Lake; and the population has a “high” hatchery influence (Lindley et al. 2007). Combined with improvements on Battle Creek that are expected to support a second population component of winter-run Chinook Salmon, the provision for fish passage upstream of Shasta Dam may support a third population, which is consistent with the NMFS Recovery Plan for this species (NMFS 2014b).

Similarly, conditions for steelhead in the American River could be influenced by fish passage at Nimbus and Folsom dams afforded by implementation of 2009 NMFS BO RPA Action II.5. As described in the Affected Environment, water temperature conditions in the lower American River downstream of Nimbus Dam currently present challenges for steelhead, especially rearing juveniles. Under the No Action Alternative, anticipated increases in temperature related to climate change could increase the vulnerability of steelhead to serious effects of elevated temperatures in most years, particularly in dry and critical dry years, even if actions are taken to improve temperature management. The provision of passage to upstream reaches of the American River, including tributaries, would give steelhead access to former spawning and rearing habitat higher in the system where water temperatures are cooler and remain cooler during the summer months. Assuming this action results in fish passage by 2030, conditions for steelhead are expected to improve because of the increased amount of available habitat and the ability to access cooler water temperatures.

Relative to recent conditions, substantial improvements also would be expected for steelhead on the Stanislaus River under the No Action Alternative, if 2009 NMFS BO RPA Action II.2.4 is determined feasible and is implemented by 2030. As described in the Affected Environment, steelhead in the Stanislaus River are exposed to multiple stressors, including high water temperatures during adult immigration, embryo incubation, juvenile rearing, and smolt outmigration. In addition, flow-dependent habitat availability is limited, particularly for the spawning, juvenile rearing, and smolt outmigration life stages. Access to former habitat in upstream areas under the No Action Alternative are anticipated to reduce many of the stressors associated with recent conditions and could provide improved resilience to climate change.

9.4.2.2.6 Ocean Conditions

Operation of the CVP and SWP would not directly affect ocean conditions; however, operations have the potential to affect Southern Resident Killer Whales indirectly by influencing the number of Chinook Salmon (produced in the Sacramento-San Joaquin River and associated tributaries) that enter the Pacific Ocean and become available as a food supply for the whales. The No Action Alternative would not directly affect critical habitat for Killer Whales. However, under the No Action Alternative, production of wild Chinook Salmon could increase with increased area and quality of habitat for Chinook Salmon, as discussed previously. Chinook Salmon from the Central Valley rivers and streams likely represent only a very small proportion of the diet of this Killer Whale population because most of their feeding is on Fraser River and Puget Sound stocks (Hanson et al. 2010). Therefore, any increase in the population of Chinook Salmon originating from the Central Valley under the No Action Alternative is not expected to substantially influence the Southern Resident Killer Whale population.

9.4.2.3 Second Basis of Comparison

As described in Chapter 3, Description of Alternatives, the Second Basis of Comparison is based upon:

- Coordinated long-term operation of the CVP and SWP in 2030 without implementation of the 2008 USFWS BO and the 2009 NMFS BO RPAs
- Changes in CVP and SWP operations due to climate change and sea level rise, and increased CVP and water rights water demand in portions of the Sacramento Valley
- Implementation of reasonable and foreseeable non-CVP and -SWP water resources projects to provide additional water supplies, as described in Section 7.4.3.1, No Action Alternative
- Implementation of RPA actions that address programs and projects that were ongoing prior to issuance of the 2008 USFWS BO and 2009 NMFS BO, including restoration of Battle Creek for salmonids; replacement of the Red Bluff Diversion Dam; restoration of more than 10,000 acres of intertidal and associated subtidal wetlands in Suisun Marsh and Cache Slough; and 17,000 to 20,000 acres of seasonal floodplain restoration in the Yolo Bypass.

Overall, under the Second Basis of Comparison, long-term average CVP and SWP water supply deliveries by 2030 through the Delta would increase, and late summer and fall reservoir storage probably would decrease as compared to recent historical conditions without consideration for climate change. However, the Second Basis of Comparison also includes changes not related to the coordinated long-term operation of the CVP and SWP, including changes in CVP and SWP operations due to climate change and sea level rise, increased CVP and water rights water demand in portions of the Sacramento Valley, and implementation of reasonable and foreseeable non-CVP or SWP water resources management projects to provide water supplies, as described under the No Action Alternative. Therefore, primarily due to climate change, both CVP and SWP reservoir storage and long-term average CVP and SWP water supply deliveries would decrease by 2030 as compared to historical long-term average deliveries.

Under the Second Basis of Comparison it is assumed that fish and aquatic resources in 2030 would continue to be influenced by CVP and SWP operations. The resulting changes in ecological attributes and subsequent effects on aquatic resources would vary geographically, as described below.

9.4.2.3.1 Trinity River Region

Aquatic Habitat Conditions in CVP and SWP Reservoirs

End of September reservoir storage in Trinity Lake would be lower by 2030 as compared to recent historical conditions due to climate change and related lower snowfall. Lewiston Reservoir, a regulating reservoir, would be operated with daily changes similar to historical conditions. These changes are not anticipated to substantially affect aquatic resources in Trinity Lake or Lewiston Reservoir relative to recent historical conditions.

Fish Habitat Conditions in Trinity and Lower Klamath Rivers

Under the Second Basis of Comparison, flow, water temperature, and aquatic habitat conditions in the Trinity River would continue to be influenced by CVP and SWP operations as described in the Affected Environment. Due to the increased potential for lower Trinity Lake surface water storage (see above), there could be an increased potential for reduced Trinity River flows during the summer and fall months under the Second Basis of Comparison as compared to recent historical conditions. The influence of climate change could result in higher water temperatures in Trinity Lake that could translate to higher release temperatures in the flow releases from Lewiston Dam and a reduction in habitat quality within the Trinity River for salmonids and other native species.

Effects Related to Water Transfers

It is not anticipated that water would be transferred to or from the Trinity River Region. It also not anticipated that water transfers would result in changes to Trinity Lake operations. Therefore, there would be no change in aquatic habitat conditions as a result of water transfers.

9.4.2.3.2 Central Valley Region

Aquatic Habitat Conditions in CVP and SWP Reservoirs

Seasonal changes in reservoir surface elevations, storage volumes, and the volume of cold water held within the reservoirs would continue under the Second Basis of

Comparison. Conditions for reservoir fishes would continue to change seasonally in response to inflow and downstream flow releases to meet demand. End of September reservoir storage would be lower by 2030 as compared to recent historical conditions in Shasta Lake, Lake Oroville, Folsom Lake, New Melones Reservoir, and San Luis Reservoir due to climate change and related lower snowfall. Whiskeytown Lake, Keswick Reservoir, Thermalito Forebay and Afterbay, and Lake Natoma are regulating reservoirs and would be operated with daily changes similar to historical conditions.

Under the Second Basis of Comparison, the magnitude of changes in seasonal surface elevation and reservoir storage could be more pronounced because of changes in the timing and intensity of storm events due to climate change and an overall reduction in snow pack. By 2030, fish in these reservoirs that spawn in shallow water (e.g., various species of black bass) could be subject to a hydrologic regime that increases the frequency of reductions in surface elevation during the spring spawning period, reducing spawning success. In addition, reduced storage volumes and reduction of the cold water pools could reduce the amount and suitability of habitat for cold water fishes (e.g., trout) within the reservoirs relative to recent historical conditions.

Aquatic Habitat Conditions in Rivers Downstream of CVP and SWP Facilities

Surface water flows are anticipated to increase during the winter months as a result of an increase in rainfall and decrease in snowfall, and to decrease in other months because of the diminished snowmelt flows in the spring and early summer months. Climate change is anticipated to result in higher water temperatures during portions of the year, with a corresponding reduction in habitat quality for salmonids and other cold water fishes. Increased downstream water demands and climate change are anticipated to contribute to an inability to maintain an adequate cold water pool in critical dry years and extended dry periods in the future.

Aquatic Habitat Conditions in Clear Creek from Whiskeytown Dam to Sacramento River

Under the Second Basis of Comparison, flow, water temperature, and aquatic habitat conditions in Clear Creek would continue to be influenced by CVP and SWP operations. Whiskeytown Reservoir would continue to be operated to convey water from the Trinity River to the Sacramento River via the Spring Creek tunnel and to release flows to Clear Creek to support anadromous fish.

The Second Basis of Comparison assumes that one of the 2009 NMFS BO RPA actions intended to improve conditions for salmonids would be implemented, 2009 NMFS BO RPA Action I.3 Spawning Gravel Augmentation, which is currently being implemented as part of the CVPIA. This action addresses the limited availability of spawning habitat in Clear Creek through the placement of gravel in selected sites in the creek. The gravel augmentation program is expected to continue under the Second Basis of Comparison, resulting in continued improvements to physical spawning habitat for steelhead, and spring-run and fall-run Chinook Salmon by 2030.

Water temperatures in Clear Creek are influenced by the temperature of water in the Whiskeytown Reservoir, ambient air temperatures, and solar radiation, and to some extent the magnitude of Whiskeytown Dam release flows. As described above for the No Action Alternative, Whiskeytown Dam has limited temperature control capabilities; however, the Spring Creek Temperature Control Curtain continues to be operated under the Second Basis of Comparison. With increasing ambient air temperature and changes in precipitation patterns as result of global warming, it may not be possible to meet the temperature targets as often in 2030 under the Second Basis of Comparison relative to recent conditions.

Aquatic Habitat Conditions in the Sacramento River from Keswick to Freeport

Under the Second Basis of Comparison, flow, water temperature, and aquatic habitat conditions in the Sacramento River downstream of Keswick Dam would continue to be influenced by CVP and SWP operations. Shasta Lake would continue to be operated to convey water from the Sacramento River to the Delta and release flows to the Sacramento River to support anadromous fish. Reclamation would continue to operate Shasta Lake to optimize use of the cold water pool and maintain carryover storage for temperature control in the Sacramento River downstream of Shasta and Keswick dams. As described above for the No Action Alternative, it is likely that temperature-related effects in the Sacramento River under the Second Basis of Comparison also would be unavoidable in some years; however, restoration of habitat in Battle Creek (see below) may compensate for these periods of unavoidably high temperatures by providing passage and habitat conditions to support a second population of winter-run Chinook Salmon.

The Red Bluff Pumping Plant and fish screen, which diverts water to the Tehama Colusa Canal and Corning Canal, was constructed to allow year-round opening of the gates at the RBDD. Allowing the dam gates at RBDD to remain open allows salmonids, sturgeon, and other fish species to pass unimpeded all year. These passage improvements are anticipated to improve conditions for fish species that spawn upstream of RBDD through improved access to spawning and rearing areas and a reduction in predation due to dispersal of predator species like Striped Bass and Sacramento Pikeminnow.

As described above for the No Action Alternative, it is anticipated that worsening temperature conditions under the Second Basis of Comparison would occur in some years as a result of increased demands for water by 2030, climate change, and less water being diverted from the Trinity River. Continued implementation of the Battle Creek Restoration Program would partially compensate for unavoidable adverse effects by restoring winter-run and spring-run Chinook Salmon habitat to the Battle Creek watershed. Full implementation of the Battle Creek Restoration Program is expected to substantially improve passage conditions for adult Chinook Salmon and steelhead relative to recent conditions. The Battle Creek Restoration Program has a goal of improving habitat for a second population component of winter-run Chinook Salmon, which could reduce the risk of extinction of the species from lost resiliency and increased vulnerability to catastrophic events.

Aquatic Habitat Conditions in the Feather River from Oroville Dam to Sacramento River

Feather River flows in the high flow channel downstream of Thermalito Dam under the Second Basis of Comparison would be influenced by regulation to meet water temperature criteria and to coordinate Lake Oroville releases and Delta export operations. Flows in the low flow channel downstream of Lake Oroville would remain similar to recent conditions. As part of the ongoing FERC relicensing process for the Oroville facilities, DWR has entered into a Settlement Agreement (DWR 2006) that includes actions to be implemented and included as terms of the anticipated FERC license. Depending on the progress of the relicensing process, these actions could be implemented by 2030 under the Second Basis of Comparison and could improve fish habitat conditions in the Feather River relative to recent conditions.

Under the terms of the Settlement Agreement, DWR will develop a comprehensive Lower Feather River Habitat Improvement Plan. Implementation of the habitat improvement plan and other actions under the terms of the Settlement Agreement is anticipated to improve habitat conditions and water quality for salmonids and other fishes using the channels of the Feather River above the confluence with the Sacramento River under the Second Basis of Comparison.

Aquatic Habitat Conditions in the American River from Nimbus Dam to Sacramento River

Reclamation releases water to the lower American River consistent with flood control requirements; existing water rights; CVP operations; the Lower American River Flow Management Standard; and SWRCB Decision 893 (D-893). Under the Second Basis of Comparison, American River flows would be influenced by releases for regulation to meet water temperature criteria, and to coordinate timed Folsom Lake releases and Delta exports. It is anticipated that conditions for fish in the lower American River under the Second Basis of Comparison would worsen relative to recent past operations of the American River Division of the CVP because of continued operation of the American River Division through 2030 to meet increasing water demands. In addition, the influence of climate change could alter hydrologic conditions in the region and affect habitat conditions for fish in the American River.

Through 2030, Reclamation would implement the flow schedule specified in the American River Flow Management Standard. The flow schedule specifies minimum flows and does not preclude Reclamation from making higher releases at Nimbus Dam. The flow schedule was developed to require more protective minimum flows in the lower American River in consideration of the river’s aquatic resources, particularly steelhead and fall-run Chinook Salmon.

Aquatic Habitat Conditions in the San Joaquin River from Friant Dam to the Stanislaus River

Under the Second Basis of Comparison, fish and aquatic habitat conditions in the San Joaquin River downstream of Friant Dam would remain similar to those described under the Affected Environment, although water temperatures could increase as a result climate change.

Aquatic Habitat Conditions in the Stanislaus River from Goodwin Dam to San Joaquin River

Under the Second Basis of Comparison, flow, water temperature, and aquatic habitat conditions in the Stanislaus River downstream of Goodwin Dam would continue to be influenced by CVP and SWP operations as described in Chapter 5, Surface Water Resources and Water Supplies. However, by 2030, conditions for fish in the Stanislaus River fish are expected to worsen relative to recent conditions because of continued operation to meet increasing water demands. In addition, the influence of climate change is expected to begin to alter hydrologic conditions in the region and affect habitat conditions for fish in the Stanislaus River.

Under the Second Basis of Comparison, management of the cold water supply within New Melones Reservoir would continue, as would cold water releases from the reservoir to provide suitable temperatures for steelhead rearing, spawning, egg incubation smoltification, and adult migration in the Stanislaus River downstream of Goodwin Dam. There are no temperature control devices at New Melones, Goodwin, or Tulloch dams, so the only mechanism for temperature management is direct flow management. This has been achieved in the recent past through a combination of augmenting baseline water operations for meeting senior water right deliveries and D-1641 water quality standards with additional flows from: 1) the CDFW fish agreement, and 2) from b(2) or b(3) water acquisitions. Access to these resources to offset operational temperature effects on steelhead in the Stanislaus River would continue to be limited, particularly in Conference Years and in drier Mid-Allocation Years. Under the Second Basis of Comparison, steelhead would likely continue to be vulnerable to the effects of elevated temperatures in dry and critical dry years. The frequency of these occurrences is expected to increase with climate change and increased water demands.

Reclamation would continue to operate releases from the East Side Division reservoirs to achieve the minimum flow schedule specified in the 1997 New Melones Interim Plan of Operations as described in Chapter 5, Surface Water Resources and Water Supplies. Because this flow schedule has been in place for a number of years, habitat conditions for steelhead and other fish species in the Stanislaus River are not anticipated to improve under the Second Basis of Comparison relative to recent conditions.

Dam operations would continue to suppress channel-forming flows that replenish spawning beds. The physical presence of the dams impedes normal sediment transportation processes. Climate change may affect the types and cover rates of vegetation upslope of the river, potentially increasing the rate of fine sediment transport to the river and to spawning areas Ongoing gravel augmentation through 2030 is anticipated to maintain or improve physical spawning habitat conditions for steelhead.

Aquatic Habitat Conditions in the Yolo Bypass (including Cache Slough, Lower Putah Creek, and Fremont Weir)

Similar to the No Action Alternative, it is assumed under the Second Basis of Comparison that restoration of up to 20,000 acres of seasonal floodplain restoration in the Yolo Bypass would occur by 2030. Actions in the Yolo Bypass also would include improvements in fish passage at Fremont Weir for anadromous salmonids, sturgeon, and other native fish species. Implementation of these ecosystem restoration actions and improvements could increase winter and spring growth and survival (relative to recent conditions) of juvenile Chinook Salmon, steelhead, and other native fish by providing increased seasonal access to productive foraging and high quality rearing habitat, depending on the extent and duration of restoration and inundation. These actions are also expected to reduce migratory delays or losses by reducing predation, straying, and delays for salmonids and other migratory native fish species.

Aquatic Habitat Conditions in the Delta

As described in Chapter 3, Description of Alternatives, the Second Basis of Comparison is based on coordinated long-term operation of the CVP and SWP in 2030 without implementation of the 2008 USFWS BO and the 2009 NMFS BO RPAs. Similar to the No Action Alternative, reasonable and foreseeable non-CVP and -SWP water resources projects to provide additional water supplies would be implemented, in addition to restoration of more than 10,000 acres of intertidal and associated subtidal wetlands in Suisun Marsh and Cache Slough; and up to 20,000 acres of seasonal floodplain restoration in the Yolo Bypass.

Under the Second Basis of Comparison, flows, water quality, and aquatic habitat conditions in the Delta would continue to be influenced by CVP and SWP operations. Climate change would result in increased stream flows in the winter and spring months during storm events due to precipitation primarily occurring as rain instead of snowfall. The increased stream flows also would increase Delta outflow. Delta outflow also would be increased in the spring and summer months as more water is released from the CVP and SWP reservoirs to maintain salinity criteria in the western Delta in response to sea level rise.

Under the Second Basis of Comparison in 2030, many years will have passed without seasonal limitations on OMR reverse (negative) flow rates, with the anticipated result that fish entrainment would occur at levels comparable to recent historical conditions. Future pumping operations would continue to expose fish to the salvage facilities and entrainment losses into the future. As described above for the No Action Alternative, recent coded wire tagging and acoustic studies have shown that survival of hatchery-origin juvenile Chinook Salmon was higher through the south Delta via the Old River route than via the San Joaquin River and that this may be due to increased survival during salvage at the facilities

(Buchanan et al. 2013, 2015; SJRGA 2013). Zeug and Cavallo (2014) suggest that entrainment losses at the diversions may be small relative to overall migration mortality.

Furthermore, operation of the permanent gates would lead to losses associated with predation at the physical structures and the local and far-field hydraulic conditions created by the barriers. Under the Second Basis of Comparison, significant reductions in the abundance of steelhead and fall-run Chinook Salmon originating in the San Joaquin River basin, (as well as the Calaveras River and Mokelumne River basins) are likely to continue.

As described above for the No Action Alternative, abundance levels for Delta Smelt, Longfin Smelt, Striped Bass, Threadfin Shad, and American Shad are currently very low, and abundance and habitat conditions for fish in the Delta in future years are difficult to predict. It is not likely that operations of the CVP and SWP under the Second Basis of Comparison would result in improvement of habitat conditions in the Delta or increases in populations for these fish by 2030, and the recent trajectory of loss would likely continue.

9.4.2.3.3 Special Status Species and Critical Habitat

Clear Creek

Clear Creek is designated critical habitat for spring-run Chinook Salmon and Central Valley steelhead. The PCEs of critical habitat for both species include freshwater spawning sites, freshwater rearing areas, and freshwater migration corridors. Spawning and rearing habitat for spring-run Chinook Salmon in Clear Creek has been negatively affected by flow and water temperature conditions associated with current operations. Under the Second Basis of Comparison, there would be little change in the PCEs of critical habitat for spring-run Chinook Salmon and Central Valley steelhead relative to recent conditions. Ongoing gravel augmentation in Clear Creek will likely result in improvements to Chinook Salmon and steelhead physical spawning habitat in Clear Creek. However, due to climate change, the conservation value of critical habitat for these species will likely be reduced under the Second Basis of Comparison by 2030, particularly in drier years when cold water releases cannot be maintained from Whiskeytown Dam.

Sacramento River

The Sacramento River provides three of the six PCEs essential to support one or more life stages, including freshwater spawning sites, rearing sites, and migration corridors for winter-run Chinook Salmon, spring-run Chinook Salmon, and Central Valley steelhead. The Sacramento River is also designated critical habitat for the Southern DPS of green sturgeon. Flow and temperature changes under the Second Basis of Comparison and the effects on spawning and rearing habitat quality were described previously.

As described above for the No Action Alternative, climate change is likely to reduce the conservation value of the spawning and rearing habitat PCEs of critical habitat by increasing water temperatures. The reduction in essential features of the spawning and rearing habitat PCEs could reduce the spatial structure, abundance, and productivity of salmonids.

The year-round opening of the gates at the RBDD allows salmonids to pass unimpeded, enhancing the conservation value of the PCE for migration. Critical habitat for green Sturgeon would also improve from unimpeded access to suitable spawning habitat upstream of the RBDD. The improved passage at the RBDD will increase the number of deep holding pools that adult Green Sturgeon can access, thereby increasing the conservation value of the water depth PCE. In addition, as described above, predation on salmon, steelhead, and sturgeon would be reduced relative to recent conditions when the RBDD was operational.

The No Action Alternative includes implementation of the CVPIA AFSP to reduce entrainment of juvenile anadromous fish from unscreened diversions. By providing funding to screen priority diversions as identified in the CVPIA AFSP, the loss of listed fish in water diversion channels by 2030 could be reduced. In addition, if new fish screens can be constructed so that diversions can occur at low water surface elevations to allow diversions below a flow of 5,000 cfs at Wilkins Slough, then cold water at Shasta Lake could be conserved during critical dry years for release to support winter-run and spring-run Chinook Salmon needs downstream.

American River

The lower American River downstream of Nimbus Dam is designated critical habitat for Central Valley steelhead. The PCEs of critical habitat in the lower American River include freshwater spawning sites, freshwater rearing areas, and freshwater migration corridors. Flow and temperature changes under the Second Basis of Comparison and the effects on spawning and rearing habitat quality were described previously. In addition, the influence of climate change is expected to alter hydrologic and temperature conditions in the region and adversely affect the PCEs for Central Valley steelhead critical habitat in the American River, primarily through increased water temperatures.

Stanislaus River

The lower Stanislaus River downstream of Goodwin Dam is designated critical habitat for Central Valley steelhead. The PCEs of critical habitat in the Stanislaus River include freshwater spawning sites, freshwater rearing areas, and freshwater migration corridors. Flow and temperature changes under the Second Basis of Comparison and the effects on spawning and rearing habitat quality were described previously. The PCEs for spawning and rearing habitat have been adversely affected by elimination of geomorphic processes that replenish and rejuvenate spawning riffles and inundate floodplain terraces to provide nutrients and rearing habitat for juvenile salmonids. In addition, moderation of flood events also eliminates or reduces the intensity and duration of freshets and storm flows, which adversely affects the PCE for migration corridors. The influence of climate change could begin to alter hydrologic and temperature conditions in the region and adversely affect the PCEs for Central Valley steelhead critical habitat in the Stanislaus River, primarily through increased water temperatures.

Delta

As described above for the No Action Alternative, designated critical habitat for both winter-run and spring-run Chinook Salmon lies adjacent to the location of the DCC gates and designated critical habitat for spring-run Chinook Salmon includes the DCC from its point of origin on the Sacramento River to its terminus at Snodgrass Slough. Designated critical habitat for Central Valley steelhead includes most of the Delta and its waterways; however, the DCC waterway was not included in designated critical habitat for this species.

Operation of the DCC gates under the Second Basis of Comparison will continue to affect the PCEs for critical habitat designated for spring-run Chinook Salmon and steelhead, primarily, the use of the Sacramento River as a migratory corridor. The operation of the gates permits fish to enter habitat and waterways they would not normally have access to with substantially higher predation risks than the migratory corridor available in the Sacramento River channel. Operation of the gates can have a direct effect on the entrainment rate and hence the functioning of the Sacramento River as a migratory corridor. Without the modifications to DCC gate operations to reduce loss of emigrating salmonids and green sturgeon described for the No Action Alternative, entrainment in the DCC will continue to be similar to recent historical conditions.

9.4.2.3.4 Effects Related to Cross Delta Water Transfers

As described under the No Action Alternative, 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 associated with changes in reservoir storage and river flow patterns. Potential effects to aquatic 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 2014d). Potential effects were identified as changes to fish in the reservoirs and in the rivers downstream of the reservoirs and the Delta. The analysis indicated that the reservoirs did not support primary populations of fish species of management concern, and that the reservoirs would continue to be operated within the historical range of operations. The analysis also indicated that mean monthly flows in the major rivers or creeks in the Sacramento and San Joaquin rivers watersheds would be similar (less than 10 percent change) with water transfers as compared to without water transfers; and therefore, changes to aquatic resources would be less than substantial. Delta conditions also would be similar with water transfers as compared to without water transfers, including less than 5 percent changes in Delta exports and less than 1.3 percent changes in Delta outflow and X2 position. Therefore, changes to aquatic resources would be less than substantial. For the purposes of this EIS, it is anticipated that similar conditions would occur due to cross Delta water transfers under the No Action Alternative and the Second Basis of Comparison.

Under the Second Basis of Comparison, water transfers could occur throughout the year depending upon limitations of available conveyance capacity and regulatory requirements.

9.4.2.3.5 Conditions for Fish Passage

Conditions for fish passage at Shasta, Folsom, and New Melones dams under the Second Basis of Comparison would be the same as described in the Affected Environment because passage of fish to river reaches above these dams would not be provided. Populations of anadromous fish under the Second Basis of Comparison would continue to be restricted to the river reaches downstream of these dams and subjected to increasing water temperatures associated primarily with climate change.

9.4.2.3.6 Ocean Conditions

Conditions for the Southern Resident Killer Whale under the Second Basis of Comparison would differ from those for the No Action Alternative, but the effects on Killer Whales would be the same.

9.4.3 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.

9.4.3.1 No Action Alternative Compared to the Second Basis of Comparison

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

9.4.3.1.1 Trinity River Region

Coho Salmon

The analysis of effects associated with changes in operation on Coho Salmon was conducted using temperature model outputs for Lewiston Dam to anticipate the likely effects on conditions in the Trinity River downstream of Lewiston Dam for Coho Salmon.

Long term average monthly water temperatures in the Trinity River at Lewiston Dam under No Action Alternative generally would be similar to the temperatures that would occur under the Second Basis of Comparison (Appendix 6B, Table B-1-4). Average monthly temperatures under the Second Basis of Comparison generally would be similar to those predicted under the No Action Alternative in most water year types, except from November through January in above- and below-normal water years when water temperatures under the No Action Alternative could be up to 1.5°F warmer than under the Second Basis of Comparison. In November of critical years, water temperatures under the No Action Alternative could be as much as 2.4°F cooler than under the Second Basis of Comparison (Appendix 6B, Table B-1-4). Average monthly water temperatures generally would be similar (less than 0.5°F difference) under the No Action Alternative and Second Basis of Comparison from July through September, except in September of wet years when temperatures would be slightly lower (0.6°F) and in August of critical years when temperatures could be slightly (0.7°F) higher under the No Action Alternative (Appendix 6B, Table B-1-4).

Overall, the temperature differences between the No Action Alternative and Second Basis of Comparison would be relatively minor and likely would have little effect on Coho Salmon in the Trinity River. The substantially lower water temperatures in November of critical dry years (and higher temperatures in December) under the No Action Alternative would likely have little effect on Coho Salmon as water temperatures in the Trinity River are typically low during this time period.

The USFWS established a water temperature threshold of 56°F for Coho Salmon spawning in the reach of the Trinity River from Lewiston Dam to the confluence with the North Fork Trinity River from October through December. Although not entirely reflective of water temperatures throughout the reach, the temperature model provides average monthly water temperature outputs for releases from Lewiston Dam, which may provide perspective on temperature conditions in the reach below. In October and November, average monthly water temperatures under both the No Action Alternative and Second Basis of Comparison would exceed 56°F at Lewiston Dam in some years (Appendix 9N). Under the No Action Alternative, the threshold would be exceeded about 8 percent of the time in October, about 1 percent more frequently than under the Second Basis of Comparison. In November, both scenarios would result in an exceedance frequency of about 2 percent. There would be no exceedance of the threshold in December under both the No Action Alternative and the Second Basis of Comparison.

Overall, the temperature model outputs for each of the Coho Salmon life stages suggest that the temperature of water released at Lewiston Dam generally would be similar under both scenarios, although the exceedance of water temperature thresholds would be slightly more frequent (1 percent) under the No Action Alternative. Given the similarity of the results and the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), it is concluded that the No Action Alternative and Second Basis of Comparison are likely to have similar effects on the Coho Salmon population in the Trinity River.

Spring-run Chinook Salmon

As described above for Coho Salmon, the temperature differences between the No Action Alternative and Second Basis of Comparison (Appendix 6B, Table B-1-4) would be relatively minor (less than 0.5°F) and likely would have little effect on spring-run Chinook Salmon in the Trinity River. The lower water temperatures in November of critical dry years (and higher temperatures in December) under the No Action Alternative would likely have little effect on spring-run Chinook Salmon as water temperatures in the Trinity River are typically low during this time period.

Under both the No Action Alternative and the Second Basis of Comparison, average monthly water temperatures in the Trinity River at Lewiston Dam would infrequently (1 percent to 2 percent of the time) exceed 60°F (Appendix 9N), the threshold for spring-run Chinook Salmon holding. There would be no difference in the frequency of exceedance of the 60°F threshold under the No Action Alternative as compared to the Second Basis of Comparison. In September, however, the threshold for spawning (56°F) would be exceeded 9 percent of the time under the No Action Alternative, which is 2 percent less frequently than under the Second Basis of Comparison (11 percent).

The differences in the frequency of threshold exceedance between the No Action Alternative and Second Basis of Comparison would be relatively minor, although temperature conditions under the No Action Alternative could be less likely to affect spring-run Chinook Salmon spawning than under the Second Basis of Comparison because of the slightly (2 percent) reduced frequency of exceedance of the 56°F threshold at Lewiston Dam in September.

Overall, water temperature differences could adversely influence spring-run Chinook Salmon in the Trinity River under the Second Basis of Comparison; however, these effects would not occur in every year and are not anticipated to be substantial based on the relatively small differences in water temperatures under the No Action Alternative as compared to the Second Basis of Comparison. In addition, the implementation of the Hatchery Management Plan (RPA Action II.6.3) under the No Action Alternative could reduce the impacts of hatchery Chinook Salmon on natural spring-run Chinook Salmon in the Trinity River and increase the genetic diversity and diversity of run-timing for these stocks relative to the Second Basis of Comparison. However, the potential magnitude of these benefits is uncertain. Thus, given these relatively minor changes in temperature and temperature threshold exceedance, the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), and the uncertainty of the hatchery benefits, it is concluded that the No Action Alternative and Second Basis of Comparison are likely to have similar effects on the spring-run Chinook Salmon in the Trinity River.

Fall-Run Chinook Salmon

The potential effects of operations on fall-run Chinook Salmon were evaluated based on water temperature differences and threshold comparisons as described above for Coho and spring-run Chinook Salmon. In addition, the Reclamation Salmon Mortality Model (Appendix 9C) was applied to examine the anticipated effects of water temperature on egg mortality.

The water temperature differences in the Trinity River at Lewiston Dam between the No Action Alternative and Second Basis of Comparison (Appendix 6B, Table B-1-4) would be relatively minor (less than 0.5°F) and likely would have little effect on fall-run Chinook Salmon. The lower water temperatures in November of critical years (and higher temperatures in December) under the No Action Alternative would likely have little effect on fall-run Chinook Salmon as water temperatures in the Trinity River are typically low during this time period.

The temperature threshold and months during which it applies for fall-run Chinook Salmon are the same as those for Coho Salmon. Under the No Action Alternative, the threshold would be exceeded about 8 percent of the time in October, about 1 percent more frequently than under the Second Basis of Comparison. In November, both conditions would result in an exceedance frequency of about 2 percent. There would be no exceedance of the threshold in December under either the No Action Alternative or the Second Basis of Comparison.

The water temperatures in the Trinity River downstream of Lewiston Dam are reflected in the analysis the Reclamation Salmon Mortality Model. For fall-run Chinook Salmon in the Trinity River, the long-term average egg mortality rate is predicted to be relatively low (around 4 percent), with higher mortality rates (nearly 15 percent) occurring in critical years under the No Action Alternative (Appendix 9C, Table B-1-1). Overall, egg mortality under the No Action Alternative and the Second Basis of Comparison would be similar.

In summary, the temperature threshold exceedance suggests that temperature conditions under the No Action Alternative could be slightly more likely to affect fall-run Chinook Salmon spawning than under the Second Basis of Comparison because of the slightly (1 percent) increased frequency of exceedance of the 56°F threshold at Lewiston Dam in October. However, this would occur prior to the peak spawning period for fall-run Chinook Salmon.

Although the combined analysis based on water temperature suggests that operations under the No Action Alternative could be slightly more adverse than under the Second Basis of Comparison, these effects would not occur in every year and are not anticipated to be substantial based on the relatively small differences in water temperatures (as well as egg mortality) between the No Action Alternative as compared to the Second Basis of Comparison. In addition, these potential adverse effects could be offset by implementation of the Hatchery Management Plan (RPA Action II.6.3) under the No Action Alternative, which could reduce the impacts of hatchery Chinook Salmon on natural fall-run Chinook Salmon in the Trinity River, and increase the genetic diversity and diversity of run-timing for these stocks relative to the Second Basis of Comparison. Overall, given the small differences in the numerical model results and the inherent uncertainty in the temperature model, as well as the potential for offsetting benefits associated with actions that were not modeled, it is concluded that the No Action Alternative and Second Basis of Comparison are likely to have similar effects on the fall-run Chinook Salmon population in the Trinity River.

Steelhead

The temperature differences between the No Action Alternative and Second Basis of Comparison (Appendix 6B) would be relatively minor (less than 0.5°F) and likely would have little effect on steelhead in the Trinity River. The substantially lower water temperatures in November of critical years (and higher temperatures in December) under the No Action Alternative would likely have little effect on steelhead as water temperatures in the Trinity River are typically low during this time period.

The temperature threshold for spawning and the months during which it applies for steelhead are the same as those for Coho Salmon. Thus, the frequency of average monthly water temperatures in the Trinity River at Lewiston Dam exceeding the spawning threshold of 56°F for steelhead would be the same as those described above for Coho Salmon. The differences in the frequency of threshold exceedance between the No Action Alternative and Second Basis of Comparison would be relatively minor, although temperature conditions under the No Action Alternative could be more likely to affect steelhead spawning than under the Second Basis of Comparison because of the slightly (1 percent) increased frequency of exceedance of the 56°F threshold at Lewiston Dam in October.

Although the combined analysis based on water temperature suggests that operations under the No Action Alternative could be slightly more adverse than under the Second Basis of Comparison, these effects would not occur in every year and are not anticipated to be substantial based on the relatively small differences in water temperatures between the No Action Alternative as compared to the Second Basis of Comparison. Overall, given these small differences and the inherent uncertainty in the temperature model, the No Action Alternative and Second Basis of Comparison are likely to have similar effects on the steelhead population in the Trinity River.

Green Sturgeon

As described in the Affected Environment and species accounts (Appendix 9B) Green Sturgeon spawn in the lower reaches of the Trinity River from April through June, and water temperatures above about 63°F are believed stressful to embryos (Van Eenennaam et al. 2005). Average monthly water temperature conditions from April through June in the Trinity River at Lewiston Dam under the No Action Alternative would be similar to temperatures under the Second Basis of Comparison and would not exceed 58°F during this period (Appendix 6B, Table B-1-4). In addition, water temperatures in the reach of the river where Green Sturgeon spawn are likely controlled by other factors (e.g., ambient air temperatures and tributary inflows) more than water operations at Trinity and Lewiston dams.

Overall, given the similarities between average monthly water temperatures at Lewiston Dam under the No Action Alternative and the Second Basis of Comparison, it is likely that temperature conditions for Green Sturgeon in the Trinity River or lower Klamath River and estuary would be similar under both scenarios.

Reservoir Fishes

The analysis of effects associated with changes in operation on reservoir fishes in Trinity Lake relied on evaluation of changes in available habitat (reservoir storage) and anticipated changes in black bass nesting success.

Changes in CVP water supplies and operations under the No Action Alternative as compared to the Second Basis of Comparison would result in lower reservoir storage in Trinity Lake. Storage in Trinity Lake could be reduced up to around 10 percent in some months of some water year types. Additional information related to monthly reservoir elevations is provided in Appendix 5A, CalSim II and DSM2 Modeling. Using storage volume is an indicator of how much habitat is available to fish species inhabiting these reservoirs, the amount of habitat for reservoir fishes could be reduced under the No Action Alternative as compared to the Second Basis of Comparison.

As shown in Appendix 9F, bass nest survival in Trinity Lake is near 100 percent in March and April in response to increasing reservoir elevations. For May, the likelihood of survival for Largemouth Bass in Trinity Lake being in the 40 to 100 percent range is slightly (about 1-2 percent) lower under the No Action Alternative as compared to the Second Basis of Comparison. For June, the likelihood of survival being greater than 40 percent for Largemouth Bass is lower than in May and is slightly (about 3 percent) higher under the No Action Alternative than the Second Basis of Comparison. For Spotted Bass, the likelihood of survival being greater than 40 percent is 100 percent in May and June under both the No Action Alternative and the Second Basis of Comparison.

Overall, the comparison of storage and the analysis of nesting suggest that effects of the No Action Alternative on reservoir fishes would be similar to those under the Second Basis of Comparison.

Pacific Lamprey

Little information is available on factors that influence populations of Pacific Lamprey in the Trinity River, but they are likely affected by many of the same factors as salmon and steelhead because of the parallels in their life cycles. On average, the temperature of water released at Lewiston Dam under the No Action Alternative would be similar to (within 0.5°F) water temperatures under the Second Basis of Comparison. Changes in CVP water supplies and operations under the No Action Alternative would result in lower reservoir storage in Trinity Lake and somewhat reduced Trinity River flows in December through February in wetter years as compared to the Second Basis of Comparison. The highest reductions in flow would be less than 10 percent in the Trinity River (Appendix 5A), with a smaller relative reduction in the lower Klamath River and Klamath River estuary.

Overall, given the similarities between average monthly water temperatures at Lewiston Dam under the No Action Alternative and the Second Basis of Comparison, it is likely that the No Action Alternative would have a similar potential to affect Pacific Lamprey in the Trinity River as the Second Basis of Comparison. This conclusion likely applies to other species of lamprey that inhabit the Trinity and lower Klamath rivers (e.g., River Lamprey).

Eulachon

As described in the Affected Environment, the last noticeable runs of Eulachon were observed in 1988 and 1989 by Yurok tribal fishers. It is unclear whether this species has been extirpated from the Klamath River. Given that the highest reductions in flow would be less than 10 percent in the Trinity River, which would represent even a smaller proportion in the lower Klamath River and Klamath River estuary, and that water temperatures in the Klamath River are unlikely to be affected by changes upstream at Lewiston Dam, it is likely that the No Action Alternative would have a similar potential to influence Eulachon in the Klamath River as would the Second Basis of Comparison.

9.4.3.1.2 Sacramento River System

Winter-run Chinook Salmon

Changes in operations that influence temperature and flow conditions in the Sacramento River downstream of Keswick Dam could affect winter-run Chinook Salmon. The following describes those changes and their potential effects.

Changes in Water Temperature

Long-term average monthly water temperatures in the Sacramento River at Keswick Dam under the No Action Alternative would generally be similar (less than 0.5°F difference) to water temperatures under the Second Basis of Comparison. An exception is during September and October of critical dry years when water temperatures could be up to 1.1°F and 0.8°F higher, respectively, under the No Action Alternative as compared to the Second Basis of Comparison and up to 1°F cooler in September of wetter years (Appendix 6B, Table B-5-4). A similar temperature pattern generally would be exhibited downstream at Ball's Ferry, Jelly's Ferry, and Bend Bridge, although average monthly temperatures would increase with average monthly temperature differences between the scenarios progressively decreasing, except in September (up to 2.8°F cooler at Bend Bridge) during wetter years under the No Action Alternative (Appendix 6B, Table B-8-4).

Overall, the temperature differences between the No Action Alternative and Second Basis of Comparison would be relatively minor (less than 0.5°F) and likely would have similar effects on winter-run Chinook Salmon in the Sacramento River. Spawning for winter-run Chinook Salmon in the Sacramento River takes place from mid-April to mid-August with incubation occurring over the same time period and extending into October. The somewhat higher water temperatures in September and October of critical dry years under the No Action Alternative could increase the likelihood of adverse effects on winter-run Chinook Salmon egg incubation during this water year type. Whereas, the reduced water temperatures during September and October under the No Action Alternative in wetter years could reduce the likelihood of adverse effects on egg incubation relative to the Second Basis of Comparison.

Changes in Exceedances of Water Temperature Thresholds

With the exception of April, average monthly water temperatures from April to September under both the No Action Alternative and Second Basis of Comparison would show exceedances of the water temperature threshold of 56°F established in the Sacramento River at Ball's Ferry for winter-run Chinook Salmon spawning and egg incubation (Appendix 9N). Under the No Action Alternative, the temperature threshold generally would be exceeded more frequently than under the Second Basis of Comparison (by about 1 percent to 3 percent) in the April through August period, with the temperature threshold in September exceeded in 42 percent of the simulated years, about 10 percent less frequently under the No Action Alternative than the Second Basis of Comparison (52 percent).

Farther downstream at Bend Bridge, the frequency of exceedances would increase, with exceedances under both the No Action Alternative and Second Basis of Comparison as high as about 90 percent in some months. Under the No Action Alternative, temperature exceedances generally would be more frequent (by up to 8 percent) than under the Second Basis of Comparison, with the exception of September, when threshold exceedances under the No Action Alternative would be about 29 percent less frequent.

Overall, there would be substantial differences in the frequency of threshold exceedance between the No Action Alternative and Second Basis of Comparison, particularly in September. Water temperature conditions under the No Action Alternative could be more likely to result in adverse effects on winter-run Chinook Salmon spawning than under the Second Basis of Comparison because of the increased frequency of exceedance of the 56°F threshold from April through August. However, the substantial reduction in the frequency of exceedance in September under the No Action Alternative may reduce the likelihood of adverse effects on winter-run Chinook Salmon egg incubation during this limited portion of the spawning and egg incubation period.

Changes in Egg Mortality

The temperatures described above for the Sacramento River downstream of Keswick Dam are reflected in the analysis of egg mortality using the Reclamation salmon mortality model (Appendix 9C). For winter-run Chinook Salmon in the Sacramento River, the long-term average temperature induced egg mortality rate is predicted to be relatively low (around 5 percent), with higher mortality rates (exceeding 20 percent) occurring in critical dry years under the No Action Alternative. In critical dry years the average egg mortality rate would be 5.4 percent greater under the No Action Alternative compared to the Second Basis of Comparison (Appendix 9C, Table B-4). Overall, egg mortality in the Sacramento River under the No Action Alternative and the Second Basis of Comparison would be similar, except in critical dry water years.

Changes in Weighted Usable Area

As described above for the assessment methodology, Weighted Usable Area (WUA) is a function of flow, but the relationship is not linear due to differences in depths and velocities present in the wetted channel at different flows. Because the combination of depths, velocities, and substrates preferred by species and life stages varies, WUA values at a given flow can differ substantially for the life stages evaluated.

As an indicator of the amount of suitable spawning habitat for winter-run Chinook Salmon between Keswick Dam and Battle Creek, modeling results indicate that, in general, there would be similar amounts of spawning habitat available from May through September under the No Action Alternative and the Second Basis of Comparison (Appendix 9E).

Modeling results indicate that, in general, there would be similar amounts of suitable fry rearing habitat available from June through October under the No Action Alternative and the Second Basis of Comparison (Appendix 9E).

Similar to the results for fry rearing WUA, modeling results indicate that there would be similar amounts of suitable juvenile rearing habitat available during the juvenile rearing period from September through August under the No Action Alternative and the Second Basis of Comparison (Appendix 9E).

Changes in SALMOD Output

SALMOD results indicate that potential juvenile production would be similar (less than 5 percent differences) under the No Action Alternative and Second Basis of Comparison in all water year types (Appendix 9D, Table B-4-16).

Changes in Delta Passage Model Output

The Delta Passage Model predicted similar estimates of annual Delta survival across the 81-year time period for winter-run Chinook Salmon between the No Action Alternative and the Second Basis of Comparison Alternative (Appendix 9J). Median Delta survival was 0.349 for the No Action Alternative and 0.352 for the Second Basis of Comparison Alternative (Appendix 9J) indicating that Delta survival of winter-run Chinook Salmon would be similar under the No Action Alternative and the Second Basis of Comparison.

Changes in Oncorhynchus Bayesian Analysis Output

Escapement of winter-run Chinook Salmon and Delta survival was modeled by the Oncorhynchus Bayesian Analysis (OBAN) model for winter-run Chinook salmon. Escapement was generally higher under the No Action Alternative as compared to the Second Basis alternative (Appendix 9I). The median escapement under the No Action Alternative was higher in 19 of the 22 years of simulation (1971 to 2002), and there was typically greater than a 25 percent chance that the No Action Alternative values would be greater than under the Second Basis of Comparison. Median delta survival was approximately 12 percent higher under the No Action Alternative as compared to the Second Basis of Comparison.

However, the probability intervals indicated that no difference between scenarios was a highly probable outcome (Appendix 9I).

Changes in Interactive Object-Oriented Simulation Output

The IOS model predicted similar adult escapement trajectories for winter-run Chinook Salmon between the No Action Alternative and the Second Basis of Comparison across the 81 years (Appendix 9H). Under the No Action Alternative, median adult escapement was 3,935 and under the Second Basis of Comparison median escapement was 4,042.

Similar to adult escapement, the IOS model predicted similar egg survival trajectories for winter-run Chinook Salmon under the No Action Alternative and the Second Basis of Comparison Alternative across the 81 water years. Under the No Action Alternative, median egg survival was 0.990 and under the Second Basis of Comparison median egg survival was 0.987 (Appendix 9H).

Changes in Delta Hydrodynamics

Winter-run Chinook Salmon smolts are most abundant in the Delta during January, February, and March. On the Sacramento River near the confluence of Georgiana Slough, the median proportion of positive velocities under the No Action Alternative was indistinguishable from the Second Basis of Comparison. On the San Joaquin River near the Mokelumne River confluence, the median percent of positive velocities was slightly higher in January and February but similar in March. In Old River downstream of the facilities, the median percent of positive velocities was substantially higher under the No Action Alternative during January, moderately higher in February and slightly higher in March. On Old River upstream of the facilities, median percent of positive velocities were moderately lower under No Action Alternative relative to Second Basis of Comparison in January but similar in February and March. On the San Joaquin River downstream of Head of Old River, the median percent of positive velocities was similar for both scenarios in January, February and March. See Appendix 9K for detailed results.

Changes in Junction Entrainment

Entrainment at Georgiana Slough was similar under both scenarios during January, February, and March when winter-run Chinook Salmon smolts are most abundant in the Delta. At the Head of Old River, median entrainment probabilities were moderately lower under the No Action Alternative during January, slightly lower during February and similar in March. At the Turner Cut junction, median entrainment probabilities under the No Action Alternative were slightly lower than the Second Basis of Comparison in January and February, and similar in March. Overall, entrainment patterns at the Columbia Cut junction were similar to those observed at Turner Cut. Patterns at the Middle River and Old River junctions were similar to those observed at Columbia and Turner Cut junctions. See Appendix 9L for detailed results.

Changes in Salvage

The median proportion salvaged of Sacramento River-origin Chinook salmon is predicted to be greater under Second Basis of Comparison relative to No Action Alternative in every month. Winter-run Chinook Salmon smolts migrating through the Delta would be most susceptible in the months of January, February, and March. Predicted values in January and February indicated a moderately reduced proportion of fish salvaged under the No Action Alternative relative to the Second Basis of Comparison. See Appendix 9M for detailed results.

Changes in Fish Passage on the Sacramento and American Rivers

The No Action Alternative includes provision for passage of winter-run Chinook Salmon at Shasta Dam. Similar actions are underway at some locations in the Pacific Northwest, but none have been attempted for large storage and flood control reservoirs such as Shasta Lake. There is considerable uncertainty about whether such a program could be effective. For example, the size of the reservoir would require that adults be transported not just into the lake, but possibly to the river many miles upstream. Also because of the size of the reservoir, successful volitional passage of juveniles through the reservoir is unlikely. Thus, in order for juvenile salmonid emigrants to contribute to the population, they must be captured in the river (or at the entrance to the lake) and provided with safe transport downstream. A high level of capture efficiency for emigrating juveniles is essential for the program to be successful at generating a self-sustaining population.

If a fish passage program could establish self-sustaining populations of winter-run Chinook Salmon, spring-run Chinook Salmon, and steelhead, it would contribute substantially to satisfaction of the spatial diversity viability standard. The passage program could also contribute to abundance and productivity, if average returns consistently exceeded approximately 500 individuals. However, the passage program could also function as a population sink if fish transported above the reservoir achieved a cohort replacement rate of less than 1.

Insufficient information is available currently the on the productivity of habitat upstream of these impoundments. Given the technical uncertainties discussed previously, it is not possible to determine if (or how much) fish passage at Shasta Dam would be likely to affect the status of Central Valley winter-run Chinook Salmon populations.

Summary of Effects on Winter-Run Chinook Salmon

The multiple model and analysis outputs described above characterize the anticipated conditions for winter-run Chinook Salmon and their response to change under the No Action Alternative as compared to the Second Basis of Comparison. For the purpose of analyzing effects on winter-run Chinook Salmon and developing conclusions, greater reliance was placed on the outputs from the two life cycle models, IOS and OBAN because they each integrate the available information to produce single estimates of winter-run Chinook Salmon escapement. The output from IOS indicated that winter-run Chinook Salmon escapement would be similar under both scenarios, whereas the OBAN results indicated that production escapement under the No Action Alternative would be higher than under the Second Basis of Comparison, although there would be some chance (less than a 25 percent) that escapement under the Second Basis of Comparison could be greater than the No Action Alternative in some years.

The model results suggest that effects on winter-run Chinook Salmon would be similar under both the No Action Alternative and Second Basis of Comparison, with a small likelihood that winter-run Chinook Salmon escapement would be higher under the No Action Alternative. This distinction, however, likely would be greater because of the potential benefits of providing fish passage under the No Action Alternative intended to address the limited availability of suitable habitat for winter-run Chinook Salmon in the Sacramento River reaches downstream of Keswick Dam. This potential beneficial effect and its magnitude would depend on the success of the fish passage program. In addition, benefits to winter-run Chinook Salmon may accrue under the No Action Alternative as a result of implementation of the 2009 NMFS BO RPA action suite (IV.4), which is intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities to improve the overall salvage survival of listed salmonids, including winter-run Chinook Salmon.

Overall, the quantitative results from the numerical models suggest that operation under the No Action Alternative would be less likely to result in adverse effects on winter-run Chinook Salmon than would operation under the Second Basis of Comparison. However, in consideration of the potentially beneficial effects resulting from the RPA actions that are not included in the numerical models (see Appendix 5A, Section B), the No Action Alternative has a much greater potential to address the long-term sustainability of winter-run Chinook Salmon than does the Second Basis of Comparison. The No Action Alternative includes provisions for fish passage upstream of Shasta Dam to address long-term temperature increases associated with climate change. The Second Basis of Comparison does not include fish passage provisions. Even though the success of fish passage is uncertain, it is concluded that the potential for adverse effects on winter-run Chinook Salmon under the No Action Alternative would be less than potential effects under the Second Basis of Comparison, principally because the Second Basis of Comparison does not include a fish passage strategy to address water temperatures that NMFS (2009) indicates is critical to winter-run Chinook Salmon sustainability over the long term with climate change by 2030.

Spring-run Chinook Salmon

Changes in operations that influence temperature and flow conditions in the Sacramento River downstream of Keswick Dam, Clear Creek downstream of Whiskeytown Dam, and Feather River downstream of Oroville Dam could affect spring-run Chinook Salmon. The following describes those changes and their potential effects.

Changes in Water Temperature

Changes in water temperature that could affect spring-run Chinook Salmon could occur in the Sacramento River, Clear Creek, and Feather River. The following describes temperature conditions in those water bodies.

Sacramento River

Long-term average monthly water temperatures in the Sacramento River at Keswick Dam under the No Action Alternative would generally be similar (less than 0.5°F difference) to water temperatures under the Second Basis of Comparison. An exception is during September and October of critical dry years when water temperatures could be up to 1.1°F and 0.8°F higher respectively, under the No Action Alternative as compared to the Second Basis of Comparison and up to 1°F cooler in September of wetter years under the No Action Alternative (Appendix 6B, Table B-5-4). A similar pattern in water temperatures generally would be exhibited downstream at Ball's Ferry, Jelly's Ferry, Bend Bridge and Red Bluff, with average monthly temperatures increasing in a downstream direction and temperature differences between scenarios progressively decreasing except in September (up to 3.2°F cooler at Red Bluff) during wetter years under the No Action Alternative (Appendix 6B, Table B-9-4).

Overall, the temperature differences between the No Action Alternative and Second Basis of Comparison would be relatively minor (less than 0.5°F) and likely would have little effect on spring-run Chinook Salmon in the Sacramento River. The somewhat lower water temperatures in September of wetter years may reduce the likelihood of adverse effects on spring-run Chinook Salmon spawning, although the increased temperatures in September of critical dry years under the No Action Alternative may increase the likelihood of adverse effects on spring-run Chinook Salmon spawning in this water year type. There would be little difference in potential effects on spring-run Chinook Salmon holding over the summer due to the similar water temperatures during this time period under the No Action Alternative and the Second Basis of Comparison.

Clear Creek

Average monthly water temperatures in Clear Creek at Igo under the No Action Alternative relative to the Second Basis of Comparison are generally predicted to be similar (less than 0.5°F differences) from September through April and June through August (Appendix 6B, Table B-3-4). Average monthly water temperatures during May under the No Action Alternative would be lower by up to 0.8°F compared to the Second Basis of Comparison. The lower water temperatures in May associated with the No Action Alternative reflect the effects of additional water discharged from Whiskeytown Dam to meet the spring attraction flow requirements to promote attraction of spring-run Chinook Salmon into the creek. While the reduction in May water temperatures indicated by the modeling could improve thermal conditions for spring-run Chinook Salmon, the duration of the two pulse flows may not be of sufficient duration (3 days each) to provide biologically meaningful temperature benefits. Overall, thermal conditions for spring-run Chinook Salmon in Clear Creek would be similar under the No Action Alternative and the Second Basis of Comparison.

Feather River

Average monthly water temperatures in the Feather River in the low flow channel generally were predicted to be similar (less than 0.5°F differences) under the No Action Alternative and Second Basis of Comparison, except during November and December when average monthly water temperatures could be up to 1.4°F higher in some water year types (Appendix 6B, Table B-20-4). Average monthly water temperatures in September under the No Action Alternative could be up to 1.3°F lower than under the Second Basis of Comparison in wetter years. Although temperatures in the river generally become progressively higher in the downstream direction, the differences between the No Action Alternative and Second Basis of Comparison exhibit a similar pattern at the downstream locations (Robinson Riffle and Gridley Bridge), with water temperature differences between the No Action Alternative and the Second Basis of Comparison generally decreasing in most water year types. However, water temperatures from July to September under the No Action Alternative could be somewhat (0.7°F to 1.6°F) cooler on average and up to 4.0°F cooler at the confluence with Sacramento River in wetter years (Appendix 6B, Table B-23-4).

Overall, the temperature differences in the Feather River between the No Action Alternative and Second Basis of Comparison would be relatively minor (less than 0.5°F) and likely would have little effect on spring-run Chinook Salmon in the Feather River. The slightly higher water temperatures in November and December under the No Action Alternative would likely have little effect on spring-run Chinook Salmon as water temperatures in the Feather River are typically low during this time period. The somewhat lower water temperatures in September of wetter years may reduce the likelihood of adverse effects on spring-run Chinook Salmon spawning, although the increased temperatures in September of critical dry years under the No Action Alternative may increase the likelihood of adverse effects on spring-run Chinook Salmon spawning in this water year type. There would be little difference in potential effects on spring-run Chinook Salmon holding over the summer due to the similar water temperatures during this time period under the No Action Alternative as compared and the Second Basis of Comparison.

Changes in Exceedances of Water Temperature Thresholds

Changes in water temperature could result in the exceedance of established water temperature thresholds for spring-run Chinook Salmon in the Sacramento River, Clear Creek, and Feather River. The following describes the extent of water temperature threshold exceedances for each of those water bodies.

Sacramento River

Average monthly water temperatures under both the No Action Alternative and Second Basis of Comparison indicate exceedances of the water temperature threshold of 56°F established in the Sacramento River at Red Bluff for spring-run Chinook Salmon (egg incubation) in October, November, and again in April. The exceedances were predicted to occur at the greatest frequency in October (82 percent of the time under the No action Alternative); the water temperature threshold would be exceeded more frequently in November (8 percent under the No Action Alternative) and not exceeded at all from December through March under the No Action Alternative (Appendix 9N). As water temperatures warm in the spring, the thresholds were predicted to be exceeded in April by 15 percent under the No Action Alternative. In the months when the greatest frequency of exceedances occur (October, November, and April), model results generally indicate more frequent exceedances (by up to 4 percent in October) under the No Action Alternative than under the Second Basis of Comparison. Temperature conditions in the Sacramento River under the No Action Alternative could be more likely to result in adverse effects on spring-run Chinook Salmon egg incubation than under the Second Basis of Comparison because of the increased frequency of exceedance of the 56°F threshold in October, November, and April. However, this difference may be partially offset if the water temperature management and fish passage measures associated with 2009 NMFS BO RPA under the No Action Alternative are successful in improving water temperatures.

Clear Creek

Average monthly water temperatures under both the No Action Alternative and Second Basis of Comparison would not exceed the water temperature threshold of 60°F established in Clear Creek at Igo for spring-run Chinook Salmon pre-spawning and rearing in June through August. However, water temperatures under the No Action Alternative and Second Basis of Comparison would exceed the water temperature threshold of 56°F established for spawning in September and October about 10 to 15 percent of the time. Water temperatures under the No Action Alternative could exceed the threshold about 3 percent more frequently than under the Second Basis of Comparison in September and about 2 percent more frequently in October (Appendix 9N). Temperature conditions in Clear Creek under the No Action Alternative could be more likely to result in adverse effects on spring-run Chinook Salmon spawning than under the Second Basis of Comparison because of the increased frequency of exceedance of the 56°F threshold in September and October. However, this difference may be partially offset if the thermal stress reduction measures associated with 2009 NMFS BO RPA Action I.1.5 under the No Action Alternative are successful in improving water temperatures in Clear Creek.

Feather River

Average monthly water temperatures under both the No Action Alternative and the Second Basis of Comparison would exceed the water temperature threshold of 56°F established in the Feather River at Robinson Riffle for spring-run Chinook Salmon egg incubation and rearing during some months, particularly in October and November, and March and April, when temperature thresholds could be exceeded frequently (Appendix 9N). The frequency of exceedance was highest in October, a month in which average monthly water could get as high as about 68°F. Water temperatures under the No Action Alternative would exceed the spawning temperature threshold about 1 percent more frequently than under the

Second Basis of Comparison in October, November, and December, and about 2 percent less frequently in March.

The established water temperature threshold of 63°F for rearing from May through August would be exceeded often under both the No Action Alternative and Second Basis of Comparison in May and June, but not at all in July and August. Water temperatures under the No Action Alternative would exceed the rearing temperature threshold about 9 percent more frequently than under the Second Basis of Comparison in May. Temperature conditions in the Feather River under the No Action Alternative could be more likely to result in adverse effects on spring-run Chinook Salmon spawning and rearing than under the Second Basis of Comparison because of the increased frequency of exceedance of the 56°F threshold from October through December.

Changes in Egg Mortality

These temperature differences described above are reflected in the analysis of egg mortality using the Reclamation salmon mortality model (Appendix 9C). For spring-run Chinook Salmon in the Sacramento River, the long-term average egg mortality rate is predicted to be relatively high (exceeding 20 percent), with high mortality rates (exceeding 70 percent) occurring in critical dry years. In critical dry years the average egg mortality rate under the No Action Alternative is predicted to be 10.4 percent greater than under the Second Basis of Comparison (Appendix 9C, Table B-3). Overall, egg mortality under the No Action Alternative and the Second Basis of Comparison would be similar, except in critical dry water years.

Changes in Weighted Usable Area

Weighted usable area curves are available for spring-run Chinook Salmon in Clear Creek. As described above, flows in Clear Creek downstream of Whiskeytown Dam are not anticipated to differ under the No Action Alternative relative to the Second Basis of Comparison except in May due to the release of spring attraction flows in accordance with the 2009 NMFS BO. Therefore, there would be no change in the amount of potentially suitable spawning and rearing habitat for spring-run Chinook Salmon (as indexed by WUA) available under the No Action Alternative as compared to the Second Basis of Comparison. However, the results of the habitat suitability/IFIM studies associated with the 2009 NMFS BO Action I.1.6 could result in changes in releases from Whiskeytown Reservoir to Clear Creek. Any changes as a result of these studies would be implemented to improve habitat for fish.

Changes in SALMOD Output

SALMOD results indicate that potential juvenile spring-run production would be similar under the No Action Alternative and the Second Basis of Comparison, except in critical dry water years when production under the No Action Alternative could be 11 percent less than under the Second Basis of Comparison (Appendix 9D, Table B-3-16).

Changes in Delta Passage Model Output

The Delta Passage Model predicted similar estimates of annual Delta survival across the 81-year time period for spring-run between the No Action Alternative and the Second Basis of Comparison (Appendix 9J). Median Delta survival was 0.296 for the No Action Alternative and 0.286 for the Second Basis of Comparison.

Changes in Delta Hydrodynamics

Spring-run Chinook Salmon are most abundant in the Delta from March through May. Near the junction of Georgiana Slough, the median percent of time that velocity was positive was similar in March, April, and May for both scenarios (Appendix 9K). Near the confluence of the San Joaquin River and the Mokelumne River, the median percent of times with positive velocities was similar in March and slightly greater under the No Action Alternative relative to the Second Basis of Comparison in April and May. A similar pattern was observed in the San Joaquin River downstream of the Head of Old River; the median percent of time that velocity was positive was similar in March, whereas values for the No Action Alternative were slightly to moderately lower relative to the Second Basis of Comparison in April and May. In Old River upstream of the facilities median percent of time with positive velocities was similar in March, slightly higher in April, and moderately higher in May under the No Action Alternative relative to the Second Basis of Comparison. In Old River downstream of the facilities, the median percent of time with positive velocity was slightly greater in March and increasingly greater in April and May under the No Action Alternative relative to the Second Basis of Comparison.

Changes in Junction Entrainment

Entrainment at Georgiana Slough was similar under both scenarios during March, April, and May when spring-run are most abundant in the Delta (Appendix 9L). At the Head of Old River, median entrainment probabilities were much greater under the No Action Alternative during April and May, whereas probabilities were similar in March. At the Turner Cut junction, median entrainment probabilities under the No Action Alternative and the Second Basis of Comparison were similar in March. During April and May, median entrainment probabilities were more divergent with moderately lower values for the No Action Alternative relative to the Second Basis of Comparison. Overall, entrainment was slightly lower at the Columbia Cut junction relative to Turner Cut, but patterns of median entrainment probabilities between the scenarios were similar. Patterns of entrainment probability at the Middle River and Old River junctions were similar to those observed at Columbia and Turner Cut junctions.

Changes in Salvage

Salvage of Sacramento River-origin Chinook Salmon is predicted to be lower under the No Action Alternative relative to the Second Basis of Comparison in every month (Appendix 9M). Spring-run smolts migrating through the Delta would be most susceptible in the months of March, April, and May. Predicted values in April and May indicated a substantially reduced fraction of fish salvaged under the No Action Alternative. Predicted salvage was more similar in March, but still moderately lower under the No Action Alternative than under the Second Basis of Comparison.

Summary of Effects on Spring-Run Chinook Salmon

The multiple model and analysis outputs described above characterize the anticipated conditions for spring-run Chinook Salmon and their response to change under the No Action Alternative as compared to the Second Basis of Comparison. For the purpose of analyzing effects on spring-run Chinook Salmon in the Sacramento River, greater reliance was placed on the outputs from the SALMOD model because it integrates the available information on temperature and flows to produce estimates of mortality for each life stage and an overall, integrated estimate of potential spring-run Chinook Salmon juvenile production. The output from SALMOD indicated that spring-run Chinook Salmon production in the Sacramento River would be similar under the No Action Alternative and the Second Basis of Comparison, although production under the No Action Alternative could be over 10 percent less than under the Second Basis of Comparison in critical dry years. The analyses attempting to assess the effects on routing, entrainment, and salvage of juvenile salmonids in the Delta suggest that salvage (as an indicator of potential losses of juvenile salmon at the export facilities) of Sacramento River-origin Chinook Salmon is predicted to be lower under the No Action Alternative relative to the Second Basis of Comparison in every month.

In Clear Creek and the Feather River, the analysis of the effects of the No Action Alternative and Second Basis of Comparison for spring-run Chinook Salmon relied on output from the WUA analysis and water temperature output for Clear Creek at Igo, and in the Feather River low flow channel and downstream of the Thermalito complex. The WUA analysis suggests that there would be little difference in the availability of spawning and rearing habitat in Clear Creek. The temperature model outputs suggest that thermal conditions and effects on each of the spring-run Chinook Salmon life stages generally would be similar under both scenarios in Clear Creek and the Feather River, although water temperatures could be somewhat less suitable for spring-run Chinook Salmon holding and spawning/egg incubation in the Feather River under the No Action Alternative. This conclusion is supported by the water temperature threshold exceedance analysis that indicated that water temperature thresholds for spawning and egg incubation would be exceeded slightly more frequently under the No Action Alternative in Clear Creek and the Feather River. The water temperature threshold for rearing spring-run Chinook Salmon would also be exceeded slightly more frequently in the Feather River. Because of the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), the slightly greater likelihood of exceeding water temperature thresholds under the No Action Alternative could increase the potential for adverse effects on the spring-run Chinook Salmon populations in the Feather River. Given the similarity of the results, the No Action Alternative and Second Basis of

Comparison are likely to have similar effects on the spring-run Chinook Salmon population in Clear Creek.

The numerical model results suggest that, overall, effects on spring-run Chinook Salmon could be slightly more adverse under the No Action Alternative than under the Second Basis of Comparison, and with a small likelihood that spring-run Chinook Salmon production would be lower under the No Action Alternative. This potential distinction between the two scenarios, however, may be offset by the benefits of implementation of fish passage under the No Action Alternative intended to address the limited availability of suitable habitat for spring-run Chinook Salmon in the Sacramento River reaches downstream of Keswick Dam. This beneficial effect and its magnitude would depend on the success of the fish passage program. In addition, spring-run Chinook Salmon may benefit under the No Action Alternative by implementation of the 2009 NMFS BO RPA action suite (IV.4), which is intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities to improve the overall salvage survival of listed salmonids, including spring-run Chinook Salmon.

Thus, it is concluded that the potential for adverse effects on spring-run Chinook Salmon under the No Action Alternative suggested by the results of the numerical models may be offset by the potential benefits of the RPA actions that are not included in the numerical models, principally because the Second Basis of Comparison does not include a fish passage strategy to address water temperatures that NMFS (2009) indicates is critical to spring-run Chinook Salmon sustainability over the long term with climate change by 2030. On balance and over the long term, the adverse effects on spring-run Chinook Salmon under the No Action Alternative would be less than those under the Second Basis of Comparison.

Fall-Run Chinook Salmon

Changes in operations that influence temperature and flow conditions in the Sacramento River downstream of Keswick Dam, Clear Creek downstream of Whiskeytown Dam, Feather River downstream of Oroville Dam and American River below Nimbus could affect fall-run Chinook Salmon. The following describes those changes and their potential effects.

Changes in Water Temperature

Changes in water temperature could affect fall-run Chinook Salmon in the Sacramento, Feather, and American rivers, and Clear Creek. The following describes temperature conditions in those water bodies.

Sacramento River

Average monthly water temperatures in the Sacramento River at Keswick Dam under the No Action Alternative would generally be similar (less than 0.5°F difference) to water temperatures under the Second Basis of Comparison. An exception is during September and October of critical dry years when water temperatures could be up to 1.1°F and 0.8°F higher, respectively, under the No Action Alternative as compared to the Second Basis of Comparison and up to 1°F cooler in September of wetter years under the No Action Alternative (Appendix 6B). A similar pattern in temperature differences generally would be exhibited at downstream locations along the Sacramento River (i.e., Ball's Ferry Jelly's Ferry, Bend Bridge, Red Bluff, Hamilton City, and Knights Landing), with average monthly temperatures increasing in a downstream direction and temperature differences between scenarios at Knights Landing progressively increasing (up to 0.9°F warmer) in June and up to 4.6°F cooler in September during the wetter years under the No Action Alternative relative to the Second Basis of Comparison.

Overall, the temperature differences between the No Action Alternative and Second Basis of Comparison would be relatively minor (less than 0.5°F) and likely would have little effect on fall-run Chinook Salmon in the Sacramento River. The somewhat lower water temperatures in September of wetter years may reduce the likelihood of adverse effects on early spawning fall-run Chinook Salmon, although the increased water temperatures in September of critical dry years under the No Action Alternative may increase the likelihood of adverse effects on fall-run Chinook Salmon spawning in this water year type.

Clear Creek

Long-term average monthly water temperatures in Clear Creek at Igo under the No Action Alternative and the Second Basis of Comparison generally would be similar (less than 0.5°F differences) in most months (Appendix 6B, Table B-3-4). Modeled average monthly water temperatures during May under the No Action Alternative would be up to 0.8°F lower than under the Second Basis of Comparison. Fall-run Chinook Salmon spawn and rear in the lower portion of Clear Creek, generally downstream of Igo. Average monthly temperatures at the confluence with the Sacramento River would be similar under the No Action Alternative and the Second Basis of Comparison, except during May. Modeled average monthly water temperatures at the confluence during May could be 0.9°F to 1.3°F lower under the No Action Alternative than under the Second Basis of Comparison.

The lower water temperatures in May associated with the No Action Alternative reflect the effects of the additional water discharged from Whiskeytown Dam to meet the spring attraction flow requirements to promote attraction of spring-run Chinook Salmon into Clear Creek. While the reduction in water temperature indicated by the modeling could improve thermal conditions for fall-run Chinook Salmon, the duration of the two pulse flows may not be of sufficient duration (3 days each) to provide biologically meaningful temperature benefits. Overall, thermal conditions for fall-run Chinook Salmon in Clear Creek would be similar under the No Action Alternative and the Second Basis of Comparison.

Feather River

Long-term average monthly water temperatures in the Feather River in the low flow channel generally are predicted to be similar (less than 0.5°F differences) under the No Action Alternative and the Second Basis of Comparison, except during November and December when average monthly water temperatures could be up to 1.4°F higher in some water year types. Average monthly water temperatures in September under the No Action Alternative could be up to 1.3°F lower than under the Second Basis of Comparison in wetter years. Although temperatures in the river generally become progressively higher in the downstream direction, the differences between the No Action Alternative and Second Basis of Comparison exhibit a similar pattern at the downstream locations (Robinson Riffle and Gridley Bridge), with water temperature differences between the No Action Alternative and Second Basis of Comparison generally decreasing in most water year types. However water temperatures from July to September under the No Action Alternative could be somewhat (0.7°F to 1.6°F) cooler on average and up to 4.0°F cooler at the confluence with Sacramento River in wetter years.

Overall, the temperature differences in the Feather River between the No Action Alternative and Second Basis of Comparison would be relatively minor (less than 0.5°F) and likely would have little effect on fall-run Chinook Salmon in the Feather River. The slightly higher water temperatures in November and December under the No Action Alternative would likely have little effect on fall-run Chinook Salmon as water temperatures in the Feather River are typically low during this time period. The somewhat lower water temperatures in September of wetter years may reduce the likelihood of adverse effects on early spawning fall-run Chinook Salmon, although the increased temperatures in September of critical dry years under the No Action Alternative may increase the likelihood of adverse effects on fall-run Chinook Salmon spawning in this water year type.

American River

Average monthly water temperatures in the American River at Nimbus Dam under the No Action Alternative generally would be similar (differences less than 0.5°F) to the Second Basis of Comparison, with the exception of June and August, when temperatures under the No Action Alternative could be as much as 0.9°F higher in below normal years (Appendix 6B, Table B-12-4). This pattern generally would persist downstream to Watt Avenue and the mouth, although temperatures under the No Action Alternative would be up to 1.6°F and 2.0°F greater, respectively, than under the Second Basis of Comparison in June. In addition, average monthly water temperatures at the mouth generally would be lower under the No Action Alternative than the Second Basis of Comparison in September of wetter years when water temperatures under the No Action Alternative could be up to 1.7°F cooler (Appendix 6B, Table B-14-4).

Overall, the temperature differences in the American River between the No Action Alternative and Second Basis of Comparison would be relatively minor (less than 0.5°F) and likely would have little effect on fall-run Chinook Salmon in the American River. The slightly higher water temperatures in June and August in some water year types under the No Action Alternative may increase the likelihood of adverse effects on fall-run Chinook Salmon rearing in the American

River if they are present. The slightly lower water temperatures during September under the No Action Alternative would have little effect on fall-run Chinook Salmon spawning in the American River because most spawning occurs later, in November, but conditions for holding would be improved. Implementation of water temperature management structural improvements (2009 NMFS BO RPA Action II.3) could contribute to better water temperature conditions for fish in the American River under the No Action Alternative than under the Second Basis of Comparison.

Changes in Exceedances of Water Temperature Thresholds

Changes in water temperature could result in the exceedance of water temperatures that are protective of fall-run Chinook Salmon in the Sacramento River, Clear Creek, Feather River, and American River. The following describes the extent of those exceedances for each of those water bodies.

Sacramento River

Average monthly water temperatures under both the No Action Alternative and Second Basis of Comparison indicate exceedances of the water temperature threshold of 56°F established in the Sacramento River at Red Bluff for Chinook Salmon spawning and egg incubation in October, November, and again in April. In the months when the greatest frequency of exceedances occur (October, November, and April), model results generally indicate more frequent exceedances (by up to 4 percent in October) under the No Action Alternative than under the Second Basis of Comparison. Temperature conditions in the Sacramento River under the No Action Alternative could be more likely to affect fall-run Chinook Salmon spawning and egg incubation than under the Second Basis of Comparison because of the increased frequency of exceedance of the 56°F threshold in October, November, and April. However, this difference may be partially offset if water temperature management and fish passage measures associated with 2009 NMFS BO RPA under the No Action Alternative are successful.

Clear Creek

Fall-run Chinook Salmon spawning in lower Clear Creek typically occurs during October through December (USFWS 2015). Average monthly water temperatures at Igo during this period are generally below 56°F, except in October. Under the No Action Alternative, the 56°F threshold would be exceeded in October about 12 percent of the time as compared to 10 percent under the Second Basis of Comparison (Appendix 9N). At the confluence with the Sacramento River, average monthly water temperatures in October would be warmer, with 56°F exceeded nearly 20 percent of the time under the No Action Alternative, about 6 percent more frequently than under the Second Basis of Comparison (Appendix 6B, Figure B-4-1). During November and December, average monthly water temperatures generally would remain below 56°F at both locations (Appendix 6B, Figure B-4-2 and B-4-3). Temperature conditions in Clear Creek under the No Action Alternative could be more likely to result in adverse effects on fall-run Chinook Salmon spawning and egg incubation than under the Second Basis of Comparison because of the increased frequency of exceedance of the 56°F threshold in October.

For fall-run Chinook Salmon rearing (January through August), the average monthly temperatures at Igo would likely remain below the 60°F threshold in all months. Downstream at the mouth of Clear Creek, average monthly water temperatures would exceed the 60°F threshold often during the summer, but the frequency of exceedance would be similar under the No Action Alternative and the Second Basis of Comparison (Appendix 6B). Temperature conditions for fall-run Chinook Salmon rearing in Clear Creek would be similar under the No Action Alternative and the Second Basis of Comparison.

Feather River

Average monthly water temperatures under both the No Action Alternative and Second Basis of Comparison would exceed the water temperature threshold of 56°F established in the Feather River at Gridley Bridge for fall-run Chinook Salmon spawning and egg incubation during some months, particularly in October, November, March, and April, when water temperature thresholds would be exceeded frequently (Appendix 9N). The frequency of exceedance would be greatest in October, when average monthly temperatures under both the No Action Alternative and Second Basis of Comparison would be above the threshold in nearly every year. The magnitude of the exceedances would be high as well, with average monthly temperatures in October reaching about 68°F. The threshold would be exceeded under both the No Action Alternative and Second Basis of Comparison about 75 percent of the time in April. The differences between the No Action Alternative and Second Basis of Comparison, however, would be relatively small, with the No Action Alternative generally exceeding temperature thresholds about 1-2 percent more frequently than the Second Basis of Comparison during the October through April period. Temperature conditions in the Feather River under the No Action Alternative could be more likely to result in adverse effects on fall-run Chinook Salmon spawning and egg incubation than under the Second Basis of Comparison because of the increased frequency of exceedance of the 56°F threshold from October through April.

Changes in Egg Mortality

Water temperatures influence the viability of incubating fall-run Chinook Salmon eggs. The following describes the differences in egg mortality for the Sacramento, Feather, and American rivers.

Sacramento River

For fall-run Chinook Salmon in the Sacramento River, the long-term average egg mortality rate is predicted to be around 17 percent, with higher mortality rates (in excess of 35 percent) occurring in critical dry years under the No Action Alternative. Predicted egg mortality would be similar under the No Action Alternative and the Second Basis of Comparison in all water year types (Appendix 9C, Table B-1).

Feather River

For fall-run Chinook Salmon in the Feather River, the long-term average egg mortality rate is predicted to be relatively low (around 7 percent), with higher mortality rates (around 14.5 percent) occurring in critical dry years under the No Action Alternative. Predicted egg mortality would be similar under the No Action Alternative and the Second Basis of Comparison in all water year types (Appendix 9C, Table B-7).

American River

For fall-run Chinook Salmon in the American River, the long-term average egg mortality rate is predicted to range from approximately 23 to 25 percent in all water year types under the No Action Alternative. Overall, egg mortality would be similar under the No Action Alternative and the Second Basis of Comparison (Appendix 9C, Table B-6).

Changes in Weighted Usable Area

Weighted usable area, which is influenced by flow, is a measure of habitat suitability. The following describes changes in WUA for fall-run Chinook Salmon in the Sacramento, Feather, and American rivers and Clear Creek.

Sacramento River

As an indicator of the amount of suitable spawning habitat for fall-run Chinook Salmon between Keswick Dam and Battle Creek, WUA modeling results indicate that, in general, there would be lesser amounts of spawning habitat available in September and November under the No Action Alternative as compared to the Second Basis of Comparison. Fall-run spawning WUA would be similar in October and December under the No Action Alternative and the Second Basis of Comparison (Appendix 9E, Table C-11-4). The long-term average spawning WUA during September (prior to the peak spawning period) under the No Action Alternative would be more than 20 percent lower, and around 6 percent lower in November compared to the Second Basis of Comparison. November is during the peak spawning period for fall-run Chinook Salmon in the Sacramento River. Results for the reach from Battle Creek to Deer Creek show the same pattern for changes in WUA for spawning fall-run Chinook Salmon between the No Action Alternative and the Second Basis of Comparison (Appendix 9E, Table C-10-4). Overall, spawning habitat availability would be somewhat lower under the No Action Alternative relative to the Second Basis of Comparison.

Modeling results indicate that, in general, the amount of suitable fry rearing habitat available from December to March under the No Action Alternative would be similar to the amount of fry rearing habitat available under the Second Basis of Comparison (Appendix 9E, Table C-12-4).

Similar to the results for fry rearing WUA, modeling results indicate that there would be similar amounts of suitable juvenile rearing habitat available during the juvenile rearing period from February to June under the No Action Alternative and the Second Basis of Comparison. (Appendix 9E, Table C-13-4).

Clear Creek

As described above, flows in Clear Creek downstream of Whiskeytown Dam are not anticipated to differ under the No Action Alternative relative to the Second Basis of Comparison except in May due to the release of spring attraction flows in accordance with the 2009 NMFS BO. Therefore, there would be no change in the amount of potentially suitable spawning and rearing habitat for fall-run Chinook Salmon (as indexed by WUA) available under the No Action Alternative as compared to the Second Basis of Comparison.

Feather River

As described above, flows in the low flow channel of the Feather River are not anticipated to differ under the No Action Alternative relative to the Second Basis of Comparison. Therefore, there would be no change in the amount of potentially suitable spawning habitat for fall-run Chinook Salmon (as indexed by WUA) available under the No Action Alternative as compared to the Second Basis of Comparison. The majority of spawning activity by fall-run Chinook Salmon in the Feather River occurs in this reach with a lesser amount of spawning occurring downstream of the Thermalito Complex.

Modeling results indicate that, in general, there would be lesser amounts of spawning habitat available in the Feather River downstream of the Thermalito Complex during September under the No Action Alternative as compared to the Second Basis of Comparison. Fall-run Chinook Salmon spawning WUA would be similar under the No Action Alternative and Second Basis of Comparison in October and November (the peak spawning months) and in December (after the peak spawning period) in this reach (Appendix 9E, Table C-24-4). The decrease in long-term average spawning WUA during September (prior to the peak spawning period) under the No Action Alternative would be relatively large (more than 15 percent). Overall, spawning habitat availability would be similar under the No Action Alternative and the Second Basis of Comparison.

American River

Modeling results indicate that, in general, there would be similar amounts of spawning habitat available for fall-run Chinook Salmon in the American River from October through December under the No Action Alternative as compared to the Second Basis of Comparison (Appendix 9E, Table C-25-4).

Changes in SALMOD Output – Sacramento River

SALMOD results indicate that potential juvenile production would similar under the No Action Alternative and the Second Basis of Comparison, except in critical dry water years when production could be 7 percent lower under the No Action Alternative than under the Second Basis of Comparison (Appendix 9D, Table B-1-16).

Changes in Delta Passage Model Output

The Delta Passage Model predicted similar estimates of annual Delta survival across the 81-year time period for fall-run Chinook Salmon between the No Action Alternative and the Second Basis of Comparison (Appendix 9J). Median Delta survival was 0.248 for the No Action Alternative and 0.245 for the Second Basis of Comparison.

Changes in Delta Hydrodynamics

Fall-run Chinook Salmon smolts are most abundant in the Delta during the months of April, May, and June. At the junction of Georgiana Slough and the Sacramento River, the median percent of time with positive velocity was similar under both scenarios in the months of April, May and June (Appendix 9K). Near the Confluence of the San Joaquin River and the Mokelumne River, the median proportion of positive velocities was slightly greater under the No Action Alternative relative to the Second Basis of Comparison in April and May and similar in June. In Old River downstream of the facilities, the median proportion of positive velocities was substantially greater in April and May, but became more similar in June. In Old River upstream of the facilities, the median proportion of positive velocities was slightly to moderately greater for the No Action Alternative relative to the Second Basis of Comparison in April and May, respectively, and slightly lower in June. On the San Joaquin River downstream of the Head of Old River, the median proportion of positive velocities was slightly to moderately lower under the No Action Alternative relative to the Second Basis of Comparison in April and May, respectively, whereas the values were similar in June.

Changes in Junction Entrainment

Entrainment at Georgiana Slough was similar under both scenarios in most months, but was slightly lower under the No Action Alternative relative to the Second Basis of Comparison in the month of June (Appendix 9L). Median entrainment probabilities at the Head of Old River were much greater under the No Action Alternative relative to the Second Basis of Comparison during April and May. The median entrainment probability was similar under both scenarios in the month of June. At the Turner Cut junction, median entrainment probabilities under the No Action Alternative were slightly lower than the Second Basis of Comparison in June. During April and May, median entrainment probabilities were more divergent with moderately lower values for the No Action Alternative relative to the Second Basis of Comparison. Overall, entrainment was slightly lower at the Columbia Cut junction relative to Turner Cut, but patterns of entrainment between the two scenarios were similar. Patterns in entrainment probabilities at the Middle River and Old River junctions were similar to those observed at Columbia and Turner Cut junctions.

Changes in Salvage

Salvage of Sacramento River-origin Chinook Salmon is predicted to be lower under the No Action Alternative relative to the Second Basis of Comparison in every month (Appendix 9M). Fall-run smolts migrating through the Delta would be most susceptible in the months of April, May, and June. Predicted values in April and May indicated a substantially reduced fraction of fish salvaged under the No Action Alternative relative to the Second Basis of Comparison. Predicted salvage was more similar in March but still lower under the No Action Alternative.

Summary of Effects on Fall-Run Chinook Salmon

The multiple model and analysis outputs described above characterize the anticipated conditions for fall-run Chinook Salmon and their response to change under the No Action Alternative as compared to the Second Basis of Comparison. For the purpose of analyzing effects on fall-run Chinook Salmon in the Sacramento River, greater reliance was placed on the outputs from the SALMOD model because it integrates the available information on temperature and flows to produce estimates of mortality for each life stage and an overall, integrated estimate of potential fall-run Chinook Salmon juvenile production. The output from SALMOD indicated that fall-run Chinook Salmon production would be similar in most water year types under the No Action Alternative than under the Second Basis of Comparison, and up to 7 percent less than under the Second Basis of Comparison in critical dry years. The analyses attempting to assess the effects on routing, entrainment, and salvage of juvenile salmonids in the Delta suggest that salvage (as an indicator of potential losses of juvenile salmon at the export facilities) of Sacramento River-origin Chinook Salmon is predicted to be lower under the No Action Alternative relative to the Second Basis of Comparison in every month.

In Clear Creek and the Feather and American rivers, the analysis of the effects of the No Action Alternative and Second Basis of Comparison for fall-run Chinook Salmon relied on the WUA analysis for habitat and water temperature model output for the rivers at various locations downstream of the CVP and SWP facilities. The WUA analysis indicated that the availability of spawning and rearing habitat in Clear Creek and spawning habitat in the Feather and American rivers would be similar under the No Action Alternative and the Second Basis of Comparison. The temperature model outputs for each of the fall-run Chinook Salmon life stages suggest that thermal conditions and effects on fall-run Chinook Salmon in all of these streams generally would be similar under both scenarios. The water temperature threshold exceedance analysis that indicated that the water temperature thresholds for fall-run Chinook Salmon spawning and egg incubation would be exceeded slightly more frequently in the Feather River and Clear Creek under the No Action Alternative and could increase the potential for adverse effects on the fall-run Chinook Salmon populations in Clear Creek and the Feather River. Results of the analysis using Reclamation's salmon mortality model indicate that there would be little difference in fall-run Chinook Salmon egg mortality under the No Action Alternative and the Second Basis of Comparison.

These model results suggest that overall, effects on fall-run Chinook Salmon could be slightly more adverse under the No Action Alternative than under the Second Basis of Comparison, with a small likelihood that fall-run Chinook Salmon production would be lower under the No Action Alternative.

Additional RPA actions in the 2009 NMFS BO could help improve conditions for fall-run Chinook Salmon under the No Action Alternative relative to the Second Basis of Comparison, such as structural improvements for water temperature management in the American River (NMFS RPA Action II.3), development of a hatchery management plan for the Nimbus Hatchery (NMFS RPA Action II.6.3) and actions (NMFS RPA Action Suite IV.4) intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities to improve the overall salvage survival of salmonids.

The implementation of fish passage under the No Action Alternative intended to address the limited availability of suitable habitat for winter-run and spring-run Chinook Salmon in the Sacramento River reaches downstream of Shasta Dam is unlikely to benefit fall-run Chinook Salmon unless passage is provided to fall-run Chinook Salmon. It is unlikely that providing similar fish passage at Folsom Dam for steelhead would benefit fall-run Chinook Salmon for the same reason.

Overall, the results of the numerical models suggest the potential for greater adverse effects on fall-run Chinook Salmon under the No Action Alternative as compared to the Second Basis of Comparison. However, discerning a meaningful difference between these two scenarios based on the quantitative results is not possible because of the similarity in results (generally differences less than 5 percent) and the inherent uncertainty of the models. In addition, any adverse effect of the No Action Alternative could be offset by the potentially beneficial effects resulting from the RPA actions evaluated qualitatively for the No Action Alternative. Thus, it is concluded that the effects on fall-run Chinook Salmon would be less adverse under the No Action Alternative than under the Second Basis of Comparison.

Late Fall-Run Chinook Salmon

Changes in operations that influence temperature and flow conditions in the Sacramento River downstream of Keswick Dam could affect late fall-run Chinook Salmon. The following describes those changes and their potential effects.

Changes in Water Temperature

As described above, long-term average monthly water temperatures in the Sacramento River at Keswick Dam under the No Action Alternative would generally be similar (less than 0.5°F difference) to water temperatures under the Second Basis of Comparison. An exception is during September and October of critical dry years when water temperatures could be up to 1.1°F and 0.8°F higher, respectively, under the No Action Alternative as compared to the Second Basis of Comparison and up to 1°F cooler in September of wetter years under the No Action Alternative (Appendix 6B, Table 5-5-4). A similar pattern in temperature differences generally would be exhibited at downstream locations along the Sacramento River (i.e., Ball's Ferry Jelly's Ferry, Bend Bridge, Red Bluff, Hamilton City, and Knights Landing), with average monthly temperatures increasing and water temperature differences between scenarios progressively increasing (up to 0.9°F warmer) in June and up to 4.6°F cooler in September during the wetter years under the No Action Alternative relative to the Second Basis of Comparison.

Overall, the temperature differences between the No Action Alternative and Second Basis of Comparison would be relatively minor (less than 0.5°F) and likely would have little effect on late fall-run Chinook Salmon in the Sacramento

River. Spawning of late fall-run Chinook Salmon in the Sacramento River takes place from December to mid-April with incubation occurring over the same time period and extending into June. The likelihood of adverse effects on late fall-run Chinook Salmon spawning and egg incubation would be similar under the No Action Alternative and the Second Basis of Comparison due to similar water temperatures during the January to May time period.

Because late fall-run Chinook Salmon have an extended rearing period, the similar water temperatures during the summer under the No Action Alternative and Second Basis of Comparison would have similar effects on rearing fry and juvenile late fall-run Chinook Salmon in the Sacramento River. The lower water temperatures under the No Action Alternative in September of wetter years may reduce the likelihood of adverse effects on fry and juvenile late fall-run Chinook Salmon in the Sacramento River during this limited time period.

Changes in Exceedances of Water Temperature Thresholds

Average monthly water temperatures under both the No Action Alternative and Second Basis of Comparison indicate exceedances of the water temperature threshold of 56°F established in the Sacramento River at Red Bluff for Chinook Salmon spawning and egg incubation in October, November, and again in April. There would be no exceedances of the threshold from December to March under both the No Action Alternative and the Second Basis of Comparison. In April, model results indicate that water temperatures under the No Action Alternative could exceed the threshold about 2 percent more frequently than under the Second Basis of Comparison. Temperature conditions in the Sacramento River under the No Action Alternative could be slightly more likely to affect late fall-run Chinook Salmon spawning and egg incubation than under the Second Basis of Comparison because of the increased frequency of exceedance of the 56°F threshold in April. However, this difference may be partially offset if water temperature management and fish passage measures associated with 2009 NMFS BO RPA under the No Action Alternative are successful.

Changes in Egg Mortality

For late fall-run Chinook Salmon in the Sacramento River, the long-term average egg mortality rate is predicted to range from approximately 2.5 to nearly 5 percent in all water year types under the No Action Alternative. Overall, egg mortality would be similar under the No Action Alternative and the Second Basis of Comparison (Appendix 9C, Table B-2).

Changes in Weighted Usable Area

Modeling results indicate that there would be similar amounts of spawning habitat available for late fall-run Chinook Salmon in the Sacramento River from January through April under the No Action Alternative and the Second Basis of Comparison (Appendix 9E, Table C-14-4). Modeling results also indicate that there would be similar amounts of suitable late fall-run Chinook Salmon fry rearing habitat available in the Sacramento River from April to June under the

No Action Alternative and Second Basis of Comparison (Appendix 9E, Table C-15-4).

A substantial fraction of late fall run Chinook Salmon juveniles oversummer in the Sacramento River before emigrating, which allows them to avoid predation through both their larger size and greater swimming ability. One implication of this life history strategy is that rearing habitat is most likely the limiting factor for late-fall-run Chinook Salmon, especially if availability of cool water determines the downstream extent of spawning habitat for late-fall-run Chinook Salmon. Modeling results indicate that, there would generally be similar amounts of suitable juvenile rearing habitat available from December through August under the No Action Alternative and Second Basis of Comparison. There could be decreases in the amount of late fall-run Chinook Salmon juvenile rearing WUA in September and November of up to 15 percent (Appendix 9E, Table C-16-4). Overall, late fall-run juvenile rearing habitat availability would be similar under the No Action Alternative and the Second Basis of Comparison.

Changes in SALMOD Output – Sacramento River

SALMOD results indicate that potential juvenile production would be similar under the No Action Alternative and the Second Basis of Comparison (Appendix 9D, Table B-2-16).

Changes in Delta Passage Model Output

For late fall-run Chinook Salmon, through-Delta survival was predicted to be slightly higher under the No Action Alternative relative to the Second Basis of Comparison for all 81 years simulated by the Delta Passage Model (Appendix 9J). Median Delta survival across all years was 0.244 for the No Action Alternative and 0.199 for the Second Basis of Comparison.

Changes in Hydrodynamics

The late fall-run Chinook Salmon migration period overlaps with winter-run Chinook Salmon. See the section on hydrodynamic analysis for winter-run Chinook Salmon for potential effects on late fall-run Chinook Salmon.

Changes in Junction Entrainment

Entrainment probabilities for late fall-run are assumed to mimic that of winter-run Chinook Salmon due to overlap in timing. See the section on winter-run Chinook Salmon entrainment for potential effects on late fall-run Chinook Salmon.

Changes in Salvage

Salvage of late fall-run Chinook Salmon is assumed to mimic that of winter-run Chinook Salmon due to overlap in timing. See the section on winter-run Chinook Salmon entrainment for potential effects on late fall-run Chinook Salmon.

Summary of Effects on Late Fall-Run Chinook Salmon

The multiple model and analysis outputs described above characterize the anticipated conditions for late fall-run Chinook Salmon and their response to change under the No Action Alternative as compared to the Second Basis of Comparison. For the purpose of analyzing effects on late fall-run Chinook

Salmon and developing conclusions, greater reliance was placed on the outputs from the SALMOD model because it integrates the available information on temperature and flows to produce estimates of mortality for each life stage and an overall, integrated estimate of potential fall-run Chinook Salmon juvenile production. The output from SALMOD indicated that late fall-run Chinook Salmon production would be similar under the No Action Alternative and the Second Basis of Comparison. The analyses attempting to assess the effects on routing, entrainment, and salvage of juvenile salmonids in the Delta suggest that salvage (as an indicator of potential losses of juvenile salmon at the export facilities) of Sacramento River-origin Chinook Salmon is predicted to be lower under the No Action Alternative relative to the Second Basis of Comparison in every month.

These model results suggest that overall, effects on late fall-run Chinook Salmon could be slightly less adverse under the No Action Alternative than under the Second Basis of Comparison. In addition, potential adverse effects may be lessened under the No Action Alternative by actions intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities (NMFS RPA Action Suite IV.4) and improve the overall salvage survival of salmonids, including late fall-run Chinook Salmon. Thus, it is concluded that the potential for adverse effects on late fall-run Chinook Salmon would be lower under the No Action Alternative compared to the Second Basis of Comparison.

Steelhead

Changes in operations that influence temperature and flow conditions could affect steelhead. The following describes those changes and their potential effects.

Changes in Water Temperature

Changes in water temperature could affect steelhead in the Sacramento, Feather, and American rivers, and Clear Creek. The following describes temperature conditions in those water bodies.

Sacramento River

As described above, long-term average monthly water temperatures in the Sacramento River at Keswick Dam under the No Action Alternative would generally be similar (less than 0.5°F difference) to water temperatures under the Second Basis of Comparison. An exception is during September and October of critical dry years when water temperatures could be up to 1.1°F and 0.8°F higher, respectively, under the No Action Alternative as compared to the Second Basis of Comparison and up to 1°F cooler in September of wetter years under the No Action Alternative (Appendix 6B, Table 5-5-4). A similar temperature pattern generally would be exhibited downstream at Ball's Ferry, Jelly's Ferry, Bend Bridge and Red Bluff, with average monthly temperatures increasing in a downstream direction and temperature differences between scenarios progressively decreasing except in September (up to a 3.2°F difference at Red Bluff) during wetter years (Appendix 6B, Table B-9-4).

Overall, the temperature differences between the No Action Alternative and Second Basis of Comparison would be relatively minor (less than 0.5°F) and likely would have little effect on steelhead in the Sacramento River. Based on the life history timing for steelhead, the slightly higher water temperatures in September of drier years under the No Action Alternative may increase the likelihood of adverse effects on steelhead adults migrating upstream in the Sacramento River. The lower water temperatures in September of wetter years under the No Action Alternative may decrease the likelihood of adverse effects on steelhead migration compared to the Second Basis of Comparison.

Clear Creek

Long-term average monthly water temperatures in Clear Creek at Igo under the No Action Alternative and the Second Basis of Comparison generally would be similar (less than 0.5°F differences) in most months (Appendix 6B, Table B-3-4). Modeled average monthly water temperatures during May under the No Action Alternative would be up to 0.8°F lower than under the Second Basis of Comparison.

The lower water temperatures in May associated with the No Action Alternative reflect the effects of the additional water discharged from Whiskeytown Dam to meet the spring attraction flow requirements to promote attraction of spring-run Chinook Salmon into Clear Creek. While the reduction in water temperature indicated by the modeling could improve thermal conditions for steelhead, the duration of the two pulse flows may not be of sufficient duration (3 days each) to provide temperature benefits. Overall, thermal conditions for steelhead in Clear Creek would be similar under the No Action Alternative and the Second Basis of Comparison.

Feather River

Long-term average monthly water temperature in the Feather River in the low flow channel generally are predicted to be similar (less than 0.5°F differences) under the No Action Alternative and the Second Basis of Comparison, except during November and December when average monthly water temperatures could be up to 1.4°F higher in some water year types. Average monthly water temperatures in September under the No Action Alternative could be up to 1.3°F lower than the Second Basis of Comparison in wetter years. Although temperatures in the river generally become progressively higher in the downstream direction, the differences between the No Action Alternative and Second Basis of Comparison exhibit a similar pattern at the downstream locations (Robinson Riffle and Gridley Bridge), with water temperature differences between the No Action Alternative and Second Basis of Comparison generally decreasing in most water year types. However, water temperatures from July to September under the No Action Alternative could be somewhat (0.7°F to 1.6°F) cooler on average and up to 4.0°F cooler at the confluence with Sacramento River in wetter years.

Overall, the temperature differences in the Feather River between the No Action Alternative and Second Basis of Comparison would be relatively minor (less than

0.5°F) and likely would have little effect on steelhead in the Feather River. The slightly higher water temperatures in November and December under the No Action Alternative would likely have little effect on adult steelhead migration as water temperatures in the Feather River are typically low during this time period. The somewhat lower water temperatures in September of wetter years may reduce the likelihood of adverse effects on adult steelhead migrating upstream and juveniles rearing in the Feather River, although the increased temperatures in September of critical dry years under the No Action Alternative may increase the likelihood of adverse effects on migrating and rearing steelhead in this water year type.

American River

Average monthly water temperatures in the American River at Nimbus Dam under the No Action Alternative generally would be similar (differences less than 0.5°F) to the Second Basis of Comparison, with the exception of June and August, when differences under the No Action Alternative could be as much as 0.9°F higher in below normal years. This pattern generally would persist downstream to Watt Avenue and the mouth, although temperatures under the No Action Alternative would be up to 1.6°F and 2.0°F greater, respectively, than under the Second Basis of Comparison in June. In addition, average monthly water temperatures at the mouth generally would be lower under the No Action Alternative than the Second Basis of Comparison in September of wetter years when water temperatures under the No Action Alternative could be up to 1.7°F cooler.

Overall, the temperature differences between the No Action Alternative and Second Basis of Comparison would be relatively minor (less than 0.5°F) and likely would have little effect on steelhead in the American River. The slightly warmer water temperatures in June and August under the No Action Alternative may increase the likelihood of adverse effects on steelhead rearing in the American River compared to the Second Basis of Comparison.

Changes in Exceedances of Water Temperature Thresholds

Changes in water temperature could result in the exceedance of established water temperature thresholds for steelhead in the Sacramento River, Clear Creek, and Feather River. The following describes the extent of exceedance for each of those streams.

Sacramento River

As described in the life history accounts (Appendix), steelhead spawning in the mainstem Sacramento River generally occurs in the upper reaches from Keswick Dam downstream to near Balls Ferry, with most spawning concentrated near Redding. Most steelhead, however, spawn in tributaries to the Sacramento River. Spawning generally takes place in the January through March period when water temperatures in the river generally do not exceed 52°F under either the No Action Alternative or Second Basis of Comparison. While there are no established temperature thresholds for steelhead rearing in the mainstem Sacramento River, average monthly temperatures when fry and juvenile steelhead are in the river would generally remain below 56°F at Balls Ferry except in August and September when this temperature would be exceeded 30 to 40 percent of the time under both the No Action Alternative and Second Basis of Comparison. However, water temperatures in the Sacramento River at Balls Ferry would exceed 56°F about 10 percent more often in September under the Second Basis of Comparison. Overall, thermal conditions for steelhead in the Sacramento River would be similar under the No Action Alternative and the Second Basis of Comparison.

Clear Creek

While there are no established temperature thresholds for steelhead spawning in Clear Creek, average monthly water temperatures in the river generally would not exceed 48°F during the spawning period (December to April) under either the No Action Alternative or Second Basis of Comparison. Similarly, while there are no established temperature thresholds for steelhead rearing in Clear Creek, average monthly temperatures throughout the year would not exceed 56°F at Igo. Overall, thermal conditions for steelhead in Clear Creek would be similar under the No Action Alternative and the Second Basis of Comparison.

Feather River

Average monthly water temperatures under both the No Action Alternative and the Second Basis of Comparison would on occasion exceed the water temperature threshold of 56°F established in the Feather River at Robinson Riffle for steelhead spawning and incubation during some months, particularly in October and November, and March and April, when temperature thresholds could be exceeded frequently (Appendix 9N). There would be a 1 percent exceedance of the 56°F threshold in December under the No Action Alternative and no exceedances of the 56°F threshold in January and February under both the No Action Alternative and the Second Basis of Comparison. However, the differences in the frequency of exceedance between the No Action Alternative and Second Basis of Comparison during March and April would be relatively small with water temperatures under the No Action Alternative exceeding the threshold about 2 percent less frequently in March (18 percent) and the same exceedance frequency (75 percent) as the Second Basis of Comparison in April.

The established water temperature threshold of 63°F for rearing from May through August would be exceeded often under both the No Action Alternative and Second Basis of Comparison in May and June, but not at all in July and August. Water temperatures under the No Action Alternative would exceed the rearing temperature threshold about 9 percent more frequently than under the Second Basis of Comparison in May, but no more frequently in June. Temperature conditions in the Feather River under the No Action Alternative could be more likely to affect steelhead spawning and rearing than under the Second Basis of Comparison because of the increased frequency of exceedance of the 56°F spawning threshold in March and the increased frequency of exceedance of the 63°F rearing threshold in May.

American River

In the American River, the water temperature threshold for steelhead rearing (May through October) is 65°F at the Watt Avenue Bridge. Average monthly water temperatures would exceed this threshold often under both the No Action Alternative and Second Basis of Comparison, especially in the July through September period when the threshold is exceeded nearly all of the time. In addition, the magnitude of the exceedance would be high, with average monthly water temperatures sometimes higher than 76°F. The differences between the No Action Alternative and Second Basis of Comparison, however, would be relatively small and occur only in June (1 percent less frequent exceedance under the No Action Alternative), and in September, when average monthly water temperatures under the No Action Alternative would exceed 65°F about 7 percent less frequently than under the Second Basis of Comparison. Temperature conditions in the American River under the No Action Alternative could be less likely to result in adverse effects on steelhead rearing than under the Second Basis of Comparison because of the reduced frequency of exceedance of the 65°F rearing threshold.

Changes in Weighted Usable Area

The following describes changes in WUA for steelhead in the Sacramento, Feather, and American rivers and Clear Creek.

Sacramento River

Modeling results indicate that, in general, there would be similar amounts of suitable steelhead spawning habitat available from December through March under the No Action Alternative and the Second Basis of Comparison (Appendix 9E, Table C-20-4).

Clear Creek

As described above, flows in Clear Creek downstream of Whiskeytown Dam are not anticipated to differ under the No Action Alternative relative to the Second Basis of Comparison except in May due to the release of spring attraction flows in accordance with the 2009 NMFS BO. Therefore, there would be no change in the amount of potentially suitable spawning and rearing habitat for steelhead (as indexed by WUA) available under the No Action Alternative as compared to the Second Basis of Comparison.

Feather River

As described above, flows in the low flow channel of the Feather River are not anticipated to differ under the No Action Alternative relative to the Second Basis of Comparison. Therefore, there would be no change in the amount of potentially suitable spawning habitat for steelhead (as indexed by WUA) available under the No Action Alternative as compared to the Second Basis of Comparison. The majority of spawning activity by steelhead in the Feather River occurs in this reach with a lesser amount of spawning occurring downstream of the Thermalito Complex.

Modeling results indicate that, in general, there would be similar amounts of spawning habitat for steelhead in the Feather River downstream of Thermalito available from December through April under the No Action Alternative and the Second Basis of Comparison (Appendix 9E, Table C-22-4).

American River

Modeling results indicate that, in general, there would be similar amounts of spawning habitat for steelhead in the American River downstream of Nimbus Dam available from December through April under the No Action Alternative and the Second Basis of Comparison (Appendix 9E, Table C-26-4).

Changes in Delta Hydrodynamics

Sacramento River-origin steelhead generally move through the Delta during spring; however, there is less information on their timing than there is for Chinook Salmon. Thus, hydrodynamics in the entire January through June period have the potential to affect juvenile steelhead. For a description of potential hydrodynamic effects on steelhead, see the descriptions for winter-run and fall-run Chinook Salmon above.

Summary of Effects on Steelhead

The multiple model and analysis outputs described above characterize the anticipated conditions for steelhead and their response to change under the No Action Alternative as compared to the Second Basis of Comparison. The analysis of the effects of the No Action Alternative and Second Basis of Comparison for steelhead relied on the WUA analysis for habitat and water temperature model output for the rivers at various locations downstream of the CVP and SWP facilities. The WUA analysis indicated that the availability of steelhead spawning and rearing habitat in Clear Creek and steelhead spawning habitat in the Sacramento, Feather and American rivers would be similar under the No Action Alternative and the Second Basis of Comparison. The temperature model outputs for each of the steelhead life stages suggest that thermal conditions and effects on steelhead in all of these streams generally would be similar under both scenarios. This conclusion is supported by the water temperature threshold exceedance analysis that indicated that the water temperature thresholds for steelhead spawning and egg incubation would be exceeded slightly less frequently in the Feather River under the No Action Alternative, although water temperature thresholds for steelhead rearing would be exceeded more frequently during some months in the Feather River and American River under the No Action Alternative. The increased frequency of exceedance of rearing temperature thresholds under the No Action Alternative could increase the potential for adverse effects on the steelhead population in the Feather and American rivers.

These numerical model results suggest that overall, effects on steelhead could be slightly more adverse under the No Action Alternative than under the Second Basis of Comparison, particularly in the Feather and American rivers. However, implementation of a fish passage program under the No Action Alternative intended to address the limited availability of suitable habitat for steelhead in the Sacramento River reaches downstream of Keswick Dam and in the American River could provide a benefit to Central Valley steelhead in the Sacramento and American rivers. This is particularly important in light of anticipated increases in water temperature associated with climate change in 2030. In addition to fish passage, preparation and implementation of an HGMP for steelhead at the Nimbus Fish Hatchery (NMFS RPA Action Suite II.6) and actions under the No Action Alternative intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities (NMFS RPA Action Suite IV.4) could benefit steelhead under the No Action Alternative in comparison to the Second Basis of Comparison. Thus, it is concluded that the effects on steelhead would be less adverse under the No Action Alternative than under the Second Basis of Comparison.

Green Sturgeon

Potential effects on Green Sturgeon were evaluated based on anticipated water temperature conditions and exceedances of established temperature thresholds in the Sacramento and Feather rivers. In addition, potential effects on Green Sturgeon during the Delta portion of their life cycle were evaluated based on changes in Delta outflow. The effects are described and summarized below.

Changes in Water Temperature

The effects of the No Action Alternative compared to the Second Basis of Comparison on Green Sturgeon were analyzed based on water temperature model outputs and comparisons of the frequency of water temperature threshold exceedances in the Sacramento and Feather rivers.

Sacramento River

Long-term average monthly water temperatures in the Sacramento River at Keswick Dam under the No Action Alternative would generally be similar (less than 0.5°F difference) to water temperatures under the Second Basis of Comparison. An exception is during September and October of critical years when water temperatures could be up to 1.1°F and 0.8°F higher, respectively, under the No Action Alternative as compared to the Second Basis of Comparison and up to 1°F cooler in September of wetter years under the No Action Alternative (Appendix 6B). A similar pattern in temperature differences generally would be exhibited at downstream locations along the Sacramento River (i.e., Ball’s Ferry Jelly’s Ferry, Bend Bridge, Red Bluff, Hamilton City, and Knights Landing), with average monthly temperatures increasing in a downstream direction and temperature differences between scenarios at Knights Landing progressively increasing (up to 0.9°F warmer) in June and up to 4.6°F cooler in September during the wetter years under the No Action Alternative relative to the Second Basis of Comparison. Overall, the temperature differences between the No Action Alternative and Second Basis of Comparison would be relatively minor (less than 0.5°F) and likely would have little effect on Green Sturgeon in the Sacramento River.

Feather River

Long-term average monthly water temperatures in the Feather River in the low flow channel generally are predicted to be similar (less than 0.5°F differences) under the No Action Alternative and the Second Basis of Comparison, except during November and December when average monthly water temperatures could be up to 1.4°F higher in some water year types. Average monthly water temperatures in September under the No Action Alternative could be up to 1.3°F lower than the Second Basis of Comparison in wetter years. Although temperatures in the river would become progressively higher in the downstream directions, the water temperature differences between the No Action Alternative and Second Basis of Comparison exhibit a similar pattern at the downstream locations (Robinson Riffle and Gridley Bridge), with water temperature differences between the No Action Alternative and Second Basis of Comparison generally decreasing in most water year types at the confluence with Sacramento River (Appendix 6B, Table B-23-1). However, water temperatures from July to September under the No Action Alternative could be somewhat (0.7°F to 1.6°F) cooler on average and up to 4.0°F cooler at the confluence with Sacramento River in wetter years. Overall, the temperature differences between the No Action Alternative and Second Basis of Comparison would be relatively minor (less than 0.5°F) and likely would have little effect on Green Sturgeon in the Feather River.

Changes in Exceedances of Water Temperature Thresholds

Changes in water temperature could result in the exceedance of established water temperature thresholds for Green Sturgeon in the Sacramento and Feather rivers. The following describes the exceedances for each of those rivers.

Sacramento River

Average monthly water temperatures in the Sacramento River at Bend Bridge under both the No Action Alternative and Second Basis of Comparison would exceed the water temperature threshold of 63°F established for Green Sturgeon larval rearing in August and September, with exceedances under the No Action Alternative occurring about 7 percent of the time in August and about 12 percent of the time in September. This is 1 to 2 percent more frequently than under the Second Basis of Comparison. Average monthly water temperatures at Bend Bridge could exceed the threshold by up to 10 degrees (reaching 73°F) during this period. Temperature conditions in the Sacramento River under the No Action Alternative could be more likely to result in adverse effects on Green Sturgeon rearing than under the Second Basis of Comparison because of the increased frequency of exceedance of the 63°F threshold in August and September.

Feather River

Average monthly water temperatures in the Feather River at Gridley Bridge under both the No Action Alternative and Second Basis of Comparison would exceed the water temperature threshold of 64°F established for Green Sturgeon spawning, incubation, and rearing in May, June, and September; no exceedances under either scenario would occur in July and August. The frequency of exceedances would be high, with both the No Action Alternative and Second Basis of Comparison exceeding the threshold in June nearly 100 percent of the time. The magnitude of the exceedance also would be substantial, with average monthly temperatures higher than 72°F in June, and higher than 75°F in July and August. Average monthly water temperatures under the No Action Alternative would exceed the threshold about 9 percent more frequently than under the Second Basis of Comparison during May and about 35 percent less frequently in September. Temperature conditions in the Feather River under the No Action Alternative could be more likely result in adverse effects on Green Sturgeon spawning and egg incubation than under the Second Basis of Comparison because of the increased frequency of exceedance of the 64°F threshold in May. The reduction in exceedance frequency in September may have little effect on rearing Green Sturgeon as many juvenile sturgeon may have migrated downstream to the lower Sacramento River and Delta by this time.

Changes in Delta Outflow

As described in Appendix 9P, mean (March to July) Delta outflow was used an indicator of potential year class strength and the likelihood of producing a strong year class of sturgeon. The median value over the 82-year CalSim II modeling period of mean (March to July) Delta outflow was predicted to be 13 percent higher under the No Action Alternative than under the Second Basis of Comparison. In addition, the likelihood of mean (March to July) Delta outflow exceeding the threshold of 50,000 cfs was the same under both alternatives.

Summary of Effects on Green Sturgeon

The analysis of the effects of the No Action Alternative and Second Basis of Comparison for Green Sturgeon relied on water temperature model output for the Sacramento and Feather rivers at various locations downstream of Shasta Dam and the Thermalito complex. The temperature model outputs for each of these rivers suggest that thermal conditions and effects on Green Sturgeon in the Sacramento and Feather rivers generally would be slightly more adverse under the No Action Alternative. This conclusion is supported by the water temperature threshold exceedance analysis that indicated that the water temperature thresholds for Green Sturgeon spawning, incubation, and rearing would be exceeded more frequently under the No Action Alternative in the Sacramento River. The water temperature threshold for Green Sturgeon spawning, incubation, and rearing would also be exceeded more frequently during some months in the Feather River but would be exceeded substantially less frequently in September under the No Action Alternative.

The increased frequency of exceedance of temperature thresholds under the No Action Alternative could increase the potential for adverse effects on Green Sturgeon in the Sacramento and Feather rivers relative to the Second Basis of Comparison. The analysis based on Delta outflows suggests that the No Action Alternative provides higher mean (March to July) outflows which could result in stronger year classes of juvenile Green Sturgeon relative to the Second Basis of Comparison. In addition, actions under the No Action Alternative intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities could improve the overall salvage survival of Green Sturgeon. However, early life stage survival in the natal rivers is crucial in development of a strong year class. Therefore, based primarily on the analysis of water temperatures, the No Action Alternative could be more likely to result in adverse effects on Green Sturgeon than the Second Basis of Comparison.

White Sturgeon

Changes in water temperature conditions in the Sacramento River would be the same as those described above for Green Sturgeon in the Sacramento River. Overall, the temperature differences between the No Action Alternative and Second Basis of Comparison would be relatively minor (less than 0.5°F) and likely would have little effect on White Sturgeon in the Sacramento River.

The water temperature threshold established for White Sturgeon spawning and egg incubation in the Sacramento River at Hamilton City is 61°F from March through June. Although there would be no exceedances of the threshold in March and April, water temperatures under both the No Action Alternative and Second Basis of Comparison would exceed this threshold in May and June. The average monthly water temperatures in May under the No Action Alternative would exceed this threshold about 55 percent of the time (about 6 percent more frequently than under the Second Basis of Comparison). In June, average monthly water temperatures under the No Action Alternative would exceed the threshold about 86 percent of the time (about 13 percent more frequently than under the Second Basis of Comparison). Average monthly water temperatures during May and June under the No Action Alternative would as high as about 65°F which is below the 68°F threshold considered lethal for White Sturgeon eggs and may cause higher growth rates in juvenile white sturgeon. Temperature conditions in the Sacramento River under the No Action Alternative could be more likely to result in adverse effects on White Sturgeon rearing than under the Second Basis of Comparison because of the increased frequency of exceedance of the 61°F threshold in May and June.

The analysis of the effects of the No Action Alternative and Second Basis of Comparison for White Sturgeon relied on water temperature model output for the Sacramento River at various locations downstream of Shasta Dam. The temperature model outputs suggest that thermal conditions and effects on White Sturgeon in the Sacramento River generally would be slightly more adverse under the No Action Alternative. This conclusion is supported by the water temperature threshold exceedance analysis that indicated that the water temperature thresholds for White Sturgeon spawning, incubation, and rearing would be exceeded more frequently under the No Action Alternative in the Sacramento River.

Changes in Delta outflows would be the same as those described above for Green Sturgeon. Mean (March to July) Delta outflow was predicted to be 13 percent higher under the No Action Alternative than under the Second Basis of Comparison. In addition, the likelihood of mean (March to July) Delta outflow exceeding the threshold of 50,000 cfs was the same under both alternatives. In addition, actions under the No Action Alternative intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities could improve the overall salvage survival of White Sturgeon.

Overall, the increased frequency of exceedance of temperature thresholds in June under the No Action Alternative could increase the potential for effects on White Sturgeon in the Sacramento River relative to the Second Basis of Comparison, however these effects are uncertain and may include reduced spawning and/or increased growth. The analysis based on Delta outflows suggests that the No Action Alternative provides higher mean (March to July) outflows which could result in stronger year classes of juvenile White Sturgeon relative to the Second Basis of Comparison. However, early life stage survival in the natal rivers is crucial in development of a strong year class. Therefore, based primarily on the analysis of water temperatures, the No Action Alternative could be more likely to result in adverse effects on White Sturgeon than the Second Basis of Comparison.

Delta Smelt

The potential effects of the No Action Alternative as compared to the Second Basis of Comparison were analyzed based on differences in proportional entrainment and the fall abiotic index as described below.

As described in Appendix 9G, a proportional entrainment regression model (based on Kimmerer 2008, 2011) was used to simulate adult Delta Smelt entrainment, as influenced by OMR flow in December through March. Results indicate that the percentage of entrainment of migrating and spawning adult Delta Smelt under the No Action Alternative would be 7 to 8.3 percent, depending on the water year type, with a long-term average percent entrainment of 7.6 percent. Percent entrainment of adult Delta Smelt under the No Action Alternative would be similar to results under the Second Basis of Comparison.

A proportional entrainment regression model (based on Kimmerer 2008) was also used to simulate larval and early juvenile Delta Smelt entrainment, as influenced by OMR flow and location of X2 in March through June (Appendix 9G). Results indicate that the percentage of entrainment of larval and early juvenile Delta Smelt under the No Action Alternative would be 1.3 to 19.3 percent, depending on the water year type, with a long term average percent entrainment of 8.6 percent, and highest entrainment under critical water year conditions. Percent entrainment of larval and early juvenile Delta Smelt under the No Action Alternative would be lower than projected entrainment under the Second Basis of Comparison by up to 9.4 percent. Under the Second Basis of Comparison, the long-term average percent entrainment would be 15.5 percent, and highest entrainment would occur under critical water year conditions, at 23.6 percent.

The predicted position of Fall X2 (in September through December) is used as an indicator of fall abiotic habitat index for Delta Smelt. Feyrer et al. (2010) used X2 location as an indicator of the extent of habitat available with suitable salinity for the rearing of older juvenile Delta Smelt. Feyrer et al. (2010) concluded that when X2 is located downstream (west) of the confluence of the Sacramento and San Joaquin Rivers, at a distance of 70 to 80 km from the Golden Gate Bridge, there is a larger area of suitable habitat. The overlap of the low salinity zone (or

X2) with the Suisun Bay/Marsh results in a two-fold increase in the habitat index (Feyrer et al. 2010).

The average September through December X2 position in km was used to evaluate the fall abiotic habitat availability for Delta Smelt under the Alternatives. X2 values simulated in the CalSim II model for each Alternative were averaged over September through December, and compared. Results indicate that under the No Action Alternative, the X2 position would range from 75.9 km to 92.4 km, depending on the water year type, with a long term average X2 position of 84 km. The most eastward location of X2 is predicted under Critical water year conditions. The X2 positions predicted under the No Action Alternative would be similar to results under the Second Basis of Comparison in drier water year types. In wetter years, the X2 location would be further west under the No Action Alternative than under the Second Basis of Comparison, by 6.1 to 9.8 km. This difference is largely due to implementation of 2008 USFWS BO RPA Component 3 (Action 4), under the No Action Alternative, which requires Reclamation and DWR to provide sufficient Delta outflow to maintain a monthly average X2 no more eastward than 74 km in above normal and wet year types. Under the Second Basis of Comparison, the long-term average X2 position would be 88.1 km, a location that does not provide for the advantageous overlap of the low salinity zone with Suisun Bay/Marsh.

Overall, the No Action Alternative likely would result in better conditions for Delta Smelt than would the Second Basis of Comparison, primarily due to lower percentage entrainment for larval and juvenile life stages, and more favorable location of Fall X2 in wetter years, and on average. Given the current condition of the Delta Smelt population, even small differences between alternatives may be important.

Longfin Smelt

The effects of the No Action Alternative as compared to the Second Basis of Comparison were analyzed based on the direction and magnitude of OMR flows during the period (December through June) when adult, larvae, and young juvenile Longfin Smelt are present in the Delta in the vicinity of the export facilities (Appendix 5A). The analysis was augmented with calculated Longfin Smelt abundance index values (Appendix 9G) per Kimmerer et al. (2009), which is based on the assumptions that lower X2 values reflect higher flows and that transporting Longfin Smelt farther downstream leads to greater Longfin Smelt survival. The index value indicates the relative abundance of Longfin Smelt and not the calculated population.

As described in Appendix 5A, OMR flows would generally be negative in all months under the Second Basis of Comparison, with the long-term average ranging from -3,700 to -7,400 cfs from December through June; whereas the OMR flows would generally be less negative during this time period under the No Action Alternative. The greatest differences between alternatives would be in April and May, where long-term average OMR flows would be positive under the No Action Alternative (Appendix 5A, Table C-17-4). The decrease in the magnitude of negative flows, with positive flows in April and May, under the No

Action Alternative as compared to the Second Basis of Comparison suggests that it could reduce the potential for entrainment of Delta Smelt at the export facilities.

Under the No Action Alternative, Longfin Smelt abundance index values range from 1,147, under critical water year conditions, to a high of 16,635 under wet water year conditions, with a long-term average value of 7,951. Under the Second Basis of Comparison, Longfin Smelt abundance index values range from 947 during critical water year conditions to a high of 15,822 under wet water year conditions, with a long-term average value of 7,257. These results suggest that the Longfin Smelt abundance index values would be higher in every water year type under the No Action Alternative as compared to the Second Basis of Comparison, with a long-term average index for the No Action Alternative that is almost 10 percent higher than the long-term average index for the Second Basis of Comparison. For below normal, dry, and critical water years, the Longfin Smelt abundance index values would be over 20 percent higher under the No Action Alternative than under the Second Basis of Comparison, with the greatest difference (26.2 percent) predicted under dry conditions.

Overall, based on the decrease in frequency and magnitude of negative OMR flows and the higher Longfin Smelt abundance index values, especially in dry and critical years, potential adverse effects on the Longfin Smelt population under the No Action Alternative likely would be less than under the Second Basis of Comparison.

Sacramento Splittail

Sacramento Splittail could benefit from the increase in inundated floodplain resulting from implementation of 2009 NMFS BO RPA Action I.6.1, Restoration of Floodplain Rearing Habitat, which would restore 17,000 to 20,000 acres for the primary purpose of enhancing rearing habitat for juvenile salmonids. The efforts currently underway in the Yolo Bypass to comply with this action apply to all alternatives under consideration and it is assumed that a notch in the Fremont Weir (6,000 cfs capacity) will be constructed and that the inundation objectives will be met by 2030. It is not currently known if and how the notch would be operated and how flows entering the bypass would be managed to accommodate floodplain rearing.

While this action is common to all alternatives, changes in operations that influence the hydrology in the Sacramento River could affect the frequency and duration of flows available to provide inundation on the bypass. To generally evaluate the potential influence of these changes in hydrology, the flows entering the Yolo Bypass during December through April were examined to determine the differences among alternatives. It was assumed that the magnitude of flow (and flow change) roughly corresponds to the amount of inundated floodplain.

Under the No Action Alternative, flows entering the Yolo Bypass generally would be lower than under the Second Basis of Comparison from December through March, especially during wetter years (Appendix 5A, Table C-26-4). These decreases would occur during periods of relatively high flow in the bypass, and may only slightly decrease the potential area of inundation.

Overall, the slight flow decreases under the No Action Alternative could result in less spawning habitat for Sacramento Splittail than under the Second Basis of Comparison because of the decreased area of potential habitat (inundation). Given the relatively minor changes in flows into the Yolo Bypass, and the inherent uncertainty associated with the resolution of the CalSim II model (average monthly outputs), it is concluded that there would be no definitive difference in effects on Sacramento Splittail between the No Action Alternative and Second Basis of Comparison.

Reservoir Fishes

The analysis of effects associated with changes in operation on reservoir fishes relied on evaluation of changes in available habitat (reservoir storage) and anticipated changes in black bass nesting success.

Changes in Available Habitat (Storage)

As described in Chapter 5, Surface Water Resources and Water Supplies, changes in CVP and SWP water supplies and operations under the No Action Alternative as compared to the Second Basis of Comparison generally would result in lower reservoir storage in CVP and SWP reservoirs in the Central Valley Region. Storage levels in Shasta Lake, Lake Oroville, and Folsom Lake would be lower under the No Action Alternative as compared to the Second Basis of Comparison, as summarized in Tables 5.12 through 5.14, in the fall and winter months due to the inclusion of Fall X2 criteria under the No Action Alternative.

The highest reductions in Shasta Lake and Lake Oroville storage could be in excess of 20 percent. Storage in Folsom Lake could be reduced up to around 10 percent in some months of some water year types. Additional information related to monthly reservoir elevations is provided in Appendix 5A, CalSim II and DSM2 Modeling. It is anticipated that aquatic habitat within the CVP and SWP water supply reservoirs is not limiting; however, storage volume is an indicator of how much habitat is available to fish species inhabiting these reservoirs. Therefore, the amount of habitat for reservoir fishes could be reduced under the No Action Alternative as compared to the Second Basis of Comparison.

Changes in Black Bass Nesting Success

Black bass nest survival in CVP and SWP reservoirs is anticipated to be near 100 percent in March and April due to increasing reservoir elevations (Appendix 9F). For May and June, the likelihood of nest survival for Largemouth Bass in Shasta Lake being in the 40 to 100 percent range is similar under the No Action Alternative and the Second Basis of Comparison; however, nest survival of greater than 40 percent in June is likely only in about 20 percent of the years evaluated. The likelihood of nest survival for Smallmouth Bass in Shasta Lake exhibits nearly the same pattern. For Spotted Bass, the likelihood of nest survival being greater than 40 percent is generally high (near 100 percent) from March to May under both the No Action Alternative and the Second Basis of Comparison. For June, Spotted Bass nest survival would be less than for May due to greater daily reductions in water surface elevation as Shasta Lake is drawn down. The likelihood of survival being greater than 40 percent is about 10 percent higher under the No Action Alternative as compared to the Second Basis of Comparison.

For May and June, the likelihood of nest survival for Largemouth Bass in Lake Oroville being in the 40 to 100 percent range is higher under the No Action Alternative as compared to the Second Basis of Comparison; about 10 percent higher in May and 3 percent higher in June. However, June nest survival of greater than 40 percent is likely only in about 40 percent of the years evaluated. The likelihood of nest survival for Smallmouth Bass in Lake Oroville exhibits nearly the same pattern. For Spotted Bass, the likelihood of nest survival being greater than 40 percent is high (>90 percent) in May under both the No Action Alternative and the Second Basis of Comparison with the likelihood of greater than 40 percent survival similar under the No Action Alternative and the Second Basis of Comparison. For June, Spotted Bass survival would be less than for May due to greater daily reductions in water surface elevation as Lake Oroville is drawn down. The likelihood of survival being greater than 40 percent is substantially (about 20 percent) higher under the No Action Alternative as compared to the Second Basis of Comparison.

Black bass nest survival in Folsom Lake is near 100 percent in March, April, and May due to increasing reservoir elevations. For June, the likelihood of nest survival for Largemouth Bass and Smallmouth Bass in Folsom Lake being in the 40 to 100 percent range is around 5 percent higher under the No Action Alternative than under the Second Basis of Comparison. For Spotted Bass, nest survival for June would be less than for May due to greater daily reductions in water surface elevation. However, the likelihood of survival being greater than 40 percent is about 5 percent higher under the No Action Alternative as compared to the Second Basis of Comparison.

Summary of Effects on Reservoir Fishes

Reservoir storage is anticipated to be reduced under the No Action Alternative relative to the Second Basis of Comparison and this reduction could affect the amount of warm and cold water habitat available within the reservoirs. However, it is unlikely that aquatic habitat within the CVP and SWP water supply reservoirs is limiting.

The analysis of black bass nest survival based on changes in water surface elevation during the spawning period indicated that the likelihood of high (>40 percent) nest survival in most of the reservoirs under the No Action Alternative would be similar under the Second Basis of Comparison from March through May and somewhat higher in June. Most black bass spawning likely occurs prior to June, such that drawdowns during June would likely affect only a small proportion of the spawning population. Thus, it is concluded that effects on black bass nesting success would be similar under the No Action Alternative and the Second Basis of Comparison.

Pacific Lamprey

Little information is available on factors that influence populations of Pacific Lamprey in the Sacramento River, but they are likely affected by many of the same factors as salmon and steelhead because of the parallels in their life cycles.

Changes in Water Temperature

The following describes anticipated changes in average monthly water temperature in the Sacramento, Feather, and American rivers and the potential for those changes to affect Pacific Lamprey.

Sacramento River

Long-term average monthly water temperatures in the Sacramento River at Keswick Dam under the No Action Alternative would generally be similar (less than 0.5°F difference) to water temperatures under the Second Basis of Comparison. An exception is during September and October of critical dry years when water temperatures could be up to 1.1°F and 0.8°F higher, respectively, under the No Action Alternative as compared to the Second Basis of Comparison and up to 1°F cooler in September of wetter years under the No Action Alternative (Appendix 6B, Table 5-5-4). A similar temperature pattern generally would be exhibited downstream at Ball’s Ferry, Jelly’s Ferry, and Bend Bridge, with average monthly temperatures increasing in a downstream direction and temperature differences between scenarios progressively decreasing except in September (up to 2.8°F cooler) at Bend Bridge) during wetter years under the No Action Alternative. Due to the similarity of water temperatures under the No Action Alternative and Second Basis of Comparison from January through the summer, there would be little difference in potential effects on Pacific Lamprey adults during their migration, holding, and spawning periods.

Feather River

Long-term average monthly water temperature in the Feather River in the low flow channel (downstream of the Thermalito Complex) generally are predicted to be similar (less than 0.5°F differences) under the No Action Alternative and the Second Basis of Comparison, except during November and December when average monthly water temperatures could be up to 1.4°F higher in some water year types. Average monthly water temperatures in September under the No Action Alternative could be up to 1.3°F lower than under the Second Basis of Comparison in wetter years (Appendix 6B, Table B-20-4). Although temperatures in the river would become progressively higher in the downstream directions, the differences in water temperatures between the No Action Alternative and Second Basis of Comparison would exhibit a similar pattern at the downstream locations (Robinson Riffle and Gridley Bridge), with water temperature differences between the No Action Alternative and Second Basis of Comparison generally decreasing in most water year types However, water temperatures from July to September under the No Action Alternative could be somewhat (0.7°F to 1.6°F) cooler on average and up to 4.0°F cooler at the confluence with Sacramento River in wetter years (Appendix 6B, Table B-23-4).

Due to the similarity of water temperatures under the No Action Alternative and Second Basis of Comparison from January through the summer, there would be little difference in potential effects on Pacific Lamprey adults during their migration, holding, and spawning periods.

American River

Average monthly water temperatures in the American River at Nimbus Dam under the No Action Alternative generally would be similar (differences less than 0.5°F) to the Second Basis of Comparison, with the exception of during June and August, when differences under the No Action Alternative could be as much as 0.9°F higher in below normal years. This pattern generally would persist downstream to Watt Avenue and the mouth, although temperatures under the No Action Alternative would be up to 1.6°F and 2.0°F greater, respectively, than under the Second Basis of Comparison in June. In addition, average monthly water temperatures at the mouth generally would be lower under the No Action Alternative than the Second Basis of Comparison in September of wetter years when water temperatures under the No Action Alternative could be up to 1.7°F cooler. Due to the similarity of water temperatures under the No Action Alternative and Second Basis of Comparison from January through the summer, there would be little difference in potential effects on Pacific Lamprey adults during their migration, holding, and spawning periods.

Summary of Effects on Pacific Lamprey

In general, Pacific Lamprey can tolerate higher temperatures than salmonids, up to around 72°F during their entire life history. Given the relatively minor changes in water temperature and water temperature threshold exceedance, and the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), it is likely that effects on Pacific Lamprey in the Sacramento, Feather, and American rivers would be similar under the No Action Alternative and the Second Basis of Comparison. This conclusion likely applies to other species of lamprey that inhabit these rivers (e.g., River Lamprey).

Striped Bass, American Shad, and Hardhead

Changes in operations influence temperature and flow conditions that could affect Striped Bass, American Shad, and Hardhead. The following describes those changes and their potential effects.

Changes in Water Temperature

The following describes temperature conditions in the Sacramento, Feather, and American rivers.

Sacramento River

Long-term average monthly water temperatures in the Sacramento River at Keswick Dam under the No Action Alternative would generally be similar (less than 0.5°F difference) to water temperatures under the Second Basis of Comparison. An exception is during September and October of critical dry years when water temperatures could be up to 1.1°F and 0.8°F higher, respectively, under the No Action Alternative as compared to the Second Basis of Comparison and up to 1°F cooler in September of wetter years under the No Action Alternative (Appendix 6B, Table 5-5-4). A similar temperature pattern generally would be exhibited downstream at Ball's Ferry, Jelly's Ferry, and Bend Bridge, with average monthly temperatures increasing in a downstream direction and temperature differences between scenarios progressively increasing (up to 0.9°F warmer) in June and up to 4.6°F cooler in September during the wetter years under the No Action Alternative relative to the Second Basis of Comparison. In general, Striped Bass, American Shad, and Hardhead can tolerate higher temperatures than salmonids. Therefore, it is unlikely that the slightly increased temperatures during some months under the No Action Alternative would have substantial adverse effects on these species.

Feather River

Average monthly water temperature in the Feather River in the low flow channel (below the Thermalito Complex) generally were predicted to be similar (less than 0.5°F differences) under the No Action Alternative and the Second Basis of Comparison, except during November and December when average monthly water temperatures would be up to 1.4°F higher in some water year types (Appendix 6B, Table B-20-4). Average monthly water temperatures in September under the No Action Alternative could be up to 1.3°F lower than under the Second Basis of Comparison in wetter years. Although temperatures in the river would become progressively higher in the downstream directions, the differences between the No Action Alternative and Second Basis of Comparison exhibit a similar pattern at the downstream locations (Appendix 6B, Table B-23-4). As described above for the Sacramento River, Striped Bass, American Shad, and Hardhead can tolerate higher temperatures than salmonids. Therefore, it is unlikely that the slightly increased temperatures during some months under the No Action Alternative would have substantial adverse effects on these species in the Feather River.

American River

Average monthly water temperatures in the American River at Nimbus Dam under the No Action Alternative generally would be similar (differences less than 0.5°F) to the Second Basis of Comparison, with the exception of during June and August, when differences under the No Action Alternative could be as much as 0.9°F higher in below normal years. This pattern generally would persist downstream to Watt Avenue and the mouth, although temperatures under the No Action Alternative would be up to 1.6°F and 2.0°F greater, respectively, than under the Second Basis of Comparison in June. As described above for the Sacramento River, Striped Bass, American Shad, and Hardhead can tolerate higher temperatures than salmonids. Therefore, it is unlikely that the slightly increased temperatures during some months under the No Action Alternative would have substantial adverse effects on these species in the American River.

Changes in Position of X2

The No Action Alternative would result in a more westward X2 position as compared to the Second Basis of Comparison during April and May, with similar values in June (Appendix 5A, Section C Table C-16-4). Based on Kimmerer (2002) and Kimmerer et al. (2009), this change in X2 would likely increase the survival index and the habitat index as measured by salinity for Striped Bass and abundance and habitat index for American Shad.

Summary of Effects on Striped Bass, American Shad, and Hardhead

In general, Striped Bass, American Shad, and Hardhead can tolerate higher temperatures than salmonids. Given the relatively minor changes in temperature and temperature threshold exceedance, and the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), it is likely that thermal conditions for and effects on Striped Bass, American Shad, and Hardhead in the Sacramento, Feather, and American rivers would be similar under the No Action Alternative and the Second Basis of Comparison. Overall, the No Action Alternative likely would be similar for Hardhead and have a slightly lower potential for adverse effects on Striped Bass and American Shad as compared to the Second Basis of Comparison, primarily due to the potential for increased survival during larval and juvenile life stages, and more favorable location of Spring X2 on average.

9.4.3.1.3 Stanislaus River/Lower San Joaquin River

Fall-Run Chinook Salmon

Changes in operations influence temperature and flow conditions that could affect fall-run Chinook Salmon in the Stanislaus River downstream of Goodwin Dam and in the San Joaquin River downstream of the Stanislaus River confluence, as measured at Vernalis. The following describes those changes and their potential effects.

Changes in Water Temperature (Stanislaus River)

Average monthly water temperatures in the Stanislaus River at Goodwin Dam under the No Action Alternative and Second Basis of Comparison generally would be similar (differences less than 0.5°F), with small differences in critical dry years when the No Action Alternative would 0.8°F and 1.3°F warmer on average than under the Second Basis of Comparison during June and September, respectively, and 0.7°F cooler in November (Appendix 6B, Table B-17-4).

Downstream at Orange Blossom Bridge, average monthly water temperatures in October under the No Action Alternative would be lower in all water year types than the Second Basis of Comparison by as much as 1.9°F. In most other months, water temperatures under the No Action Alternative and Second Basis of Comparison generally would be similar. An exception to this pattern occurs in April when average monthly water temperatures in all but wet water year types would be lower under the No Action Alternative by as much as about 1.2°F (Appendix 6B, Table B-18-4).

This temperature pattern would continue downstream to the confluence with the San Joaquin River, although temperatures would progressively increase, as would the magnitude of difference between the No Action Alternative and Second Basis of Comparison. Decreases in average monthly water temperatures in October and April would be more pronounced under the No Action Alternative, with average differences as much as 2.7°F in October and 2.0°F in April (Appendix 6B, Table B-19-4) relative to the Second Basis of Comparison. The magnitude of differences in average monthly water temperatures between the No Action Alternative and the Second Basis of Comparison in May and June also would increase relative to the upstream locations with average June water temperatures reaching 2.4°F warmer under the No Action Alternative in wet years.

Based on the life history timing for fall-run Chinook Salmon, the lower temperatures in October under the No Action Alternative may reduce the likelihood of adverse to fall-run Chinook Salmon spawning and egg incubation as compared to the Second Basis of Comparison.

Changes in Exceedance of Water Temperature Thresholds (Stanislaus River)

While specific water temperature thresholds for fall-run Chinook Salmon in the Stanislaus River are not established, temperatures generally considered suitable for fall-run Chinook Salmon spawning (56°F) would be exceeded in October and November approximately 30 percent of the time in the Stanislaus River at Goodwin Dam under the No Action Alternative (Appendix 6B, Figures B-17-1 and B-17-2). Similar exceedances would occur under the Second Basis of Comparison, although slightly less frequently in November. Water temperatures for rearing from January to May generally would be below 56°F, except in May when average monthly water temperatures would reach about 60°F under both the No Action Alternative and the Second Basis of Comparison (Appendix 6B, Figure B-17-8).

Downstream at Orange Blossom Bridge, water temperatures suitable for fall-run Chinook Salmon spawning (56°F) would be exceeded frequently under both the No Action Alternative and Second Basis of Comparison during October and November. Under the No Action Alternative, average monthly water temperatures would exceed 56°F about 57 percent of the time in October (Appendix 6B, Figure B-18-1). This, however, would be about 28 percent less frequently than under the Second Basis of Comparison. In November, average monthly water temperatures would exceed 56°F about 33 percent of the time under the No Action Alternative, which would be about 5 percent more frequently than under the Second Basis of Comparison (Appendix 6B, Figure B-18-2).

From January through May, rearing fall-run Chinook Salmon would be subjected to average monthly water temperatures that exceed 56°F in March (less than 10 percent of the time) and May (about 30 percent of the time) under the No Action Alternative which is about 10 percent more frequently in May than under the Second Basis of Comparison (Appendix 6B, Figure B-18-8).

Changes in Egg Mortality (Stanislaus River)

For fall-run Chinook Salmon in the Stanislaus River, the long-term average egg mortality rate is predicted to be around 7 percent, with higher mortality rates (in excess of 14 percent) occurring in critical dry years under the No Action Alternative. Overall, egg mortality in the Stanislaus River would be similar under the No Action Alternative and the Second Basis of Comparison (Appendix 9C, Table B-8).

Changes in Delta Hydrodynamics

San Joaquin River-origin fall-run Chinook Salmon smolts are most abundant in the Delta during the months of April, May and June. Near the Confluence of the San Joaquin River and the Mokelumne River, the median proportion of positive velocities was slightly greater under the No Action Alternative relative to the Second Basis of Comparison in April and May and similar in June (Appendix 9K). In Old River downstream of the facilities, the median proportion of positive velocities was substantially greater in April and May, but became more similar in June. In Old River upstream of the facilities, the median proportion of positive velocities was slightly to moderately greater for the No Action Alternative relative to the Second Basis of Comparison in April and May, respectively, and slightly lower in June. On the San Joaquin River downstream of the Head of Old River, the proportion of positive velocities was slightly to moderately lower under the No Action Alternative relative to the Second Basis of Comparison in April and May, respectively, whereas the values were similar in June.

Changes in Junction Entrainment

Median entrainment probabilities at the Head of Old River were much greater under the No Action Alternative relative to the Second Basis of Comparison during April and May. The median entrainment probability was similar under both scenarios in the month of June (Appendix 9L). At the Turner Cut junction, median entrainment probabilities under the No Action Alternative were slightly lower than the Second Basis of Comparison in June. During April and May, median entrainment probabilities were more divergent with moderately lower values for the No Action Alternative relative to the Second Basis of Comparison. Overall, entrainment was slightly lower at the Columbia Cut junction relative to Turner Cut, but patterns of entrainment between these two scenarios were similar. Patterns at the Middle River and Old River junctions were similar to those observed at Columbia and Turner Cut junctions.

Changes in Fish Passage on the Stanislaus River

The No Action Alternative includes the provision of passage at New Melones Dam for steelhead. The challenges and difficulties associated with providing fish passage upstream of Shasta and Folsom dams were briefly summarized previously, and the same considerations apply to passage upstream of New Melones Dam.

If a fish passage program could establish self-sustaining populations of spring-run Chinook Salmon and steelhead upstream of New Melones, it would contribute substantially to satisfaction of the spatial diversity viability standard. The passage program could also contribute to abundance and productivity, if average returns consistently exceeded 500 individuals. However, the passage program could also function as a population sink if fish transported above the reservoir achieved a cohort replacement rate of less than 1.

Insufficient information is available currently on the quantity, suitability, and accessibility of habitat upstream of New Melones. Given poor habitat data and the considerable technical uncertainties discussed previously, it is not possible to determine if (or how much) fish passage at New Melones Dam are likely to affect the status of Central Valley spring-run Chinook Salmon and steelhead populations.

While the purpose of the fish passage action is not intended to benefit fall-run Chinook Salmon, it could provide benefit if passage is provided for fall-run Chinook Salmon.

Summary of Effects on Fall-Run Chinook Salmon

The multiple model and analysis outputs described above characterize the anticipated conditions for fall-run Chinook Salmon and their response to change under the No Action Alternative as compared to the Second Basis of Comparison. In the Stanislaus River, the analysis of the effects of the No Action Alternative and Second Basis of Comparison for fall-run Chinook Salmon relied on the water temperature model output for the rivers at various locations downstream of Goodwin Dam. The temperature model outputs for each of the fall-run Chinook Salmon life stages suggest that thermal conditions and effects on fall-run Chinook Salmon in the Stanislaus River generally would be similar under both scenarios, although water temperatures could be somewhat more suitable for fall-run Chinook Salmon spawning/egg incubation under the No Action Alternative. This conclusion is supported by the water temperature threshold exceedance analysis that indicated that suitable water temperatures for fall-run Chinook Salmon spawning and egg incubation would be exceeded slightly more frequently in November, but substantially less frequently in October under the No Action Alternative. Suitable water temperatures for fall-run Chinook Salmon rearing would be exceeded somewhat more frequently under the No Action Alternative. Results of the analysis using Reclamation’s salmon mortality model indicate that there would be little difference in fall-run Chinook Salmon egg mortality under the No Action Alternative and the Second Basis of Comparison.

Implementation of a fish passage project under the No Action Alternative, although intended to address the limited availability of suitable habitat for spring-run Chinook Salmon and steelhead in the Stanislaus River reaches downstream of Goodwin Dam, likely would provide some benefit to fall-run Chinook Salmon if passage for adult fall-run Chinook Salmon was provided and additional habitat could be accessed. Any potential benefit to fall-run Chinook Salmon is uncertain. Moreover, RPA actions intended to increase the efficiency of the Tracy and

Skinner Fish Collection Facilities could improve the overall salvage survival of fall-run Chinook Salmon.

The numerical model results for effects on fall-run Chinook Salmon under the No Action Alternative and Second Basis of Comparison do not definitively show distinct differences. Because the No Action Alternative has the potential for beneficial effects resulting from the RPA actions, it is concluded that the effects on fall-run Chinook Salmon would be less adverse under the No Action Alternative relative to the Second Basis of Comparison.

Steelhead

Changes in operations that influence temperature and flow conditions in the Stanislaus River downstream of Goodwin Dam and the San Joaquin River downstream of the Stanislaus River confluence, as measured at Vernalis could affect steelhead. The following describes those changes and their potential effects.

Changes in Water Temperature (Stanislaus River)

Average monthly water temperatures in the Stanislaus River at Goodwin Dam under the No Action Alternative and Second Basis of Comparison generally would be similar (differences less than 0.5°F), with small differences in critical dry years when water temperatures under the No Action Alternative would 0.8°F and 1.3°F warmer on average than under the Second Basis of Comparison during June and September, respectively, and 0.7°F cooler in November (Appendix 6B, Table B-17-4).

Downstream at Orange Blossom Bridge, average monthly water temperatures in October under the No Action Alternative would be lower than the Second Basis of Comparison in all water year types by as much as 1.9°F. In most other months, water temperatures under the No Action Alternative and Second Basis of Comparison generally would be similar, except in April when average monthly water temperatures would be lower under the No Action Alternative by as much as about 1.2°F in the drier years (Appendix 6B, Table B-18-4).

This temperature pattern would continue downstream to the confluence with the San Joaquin River, although temperatures would progressively increase, as would the magnitude of difference between the No Action Alternative and Second Basis of Comparison. Decreases in average monthly water temperatures in October and April would be more pronounced under the No Action Alternative, with average differences as much as 2.7°F (Appendix 6B, Table B-19-4) relative to the Second Basis of Comparison. The magnitude of differences in average monthly water temperatures between the No Action Alternative and the Second Basis of Comparison in May and June also would increase relative to the upstream locations with average June water temperatures reaching 2.4°F warmer under the No Action Alternative in wet years.

Overall, the temperature differences between the No Action Alternative and Second Basis of Comparison would be relatively minor (less than 0.5°F) and likely would have little effect on steelhead in the Stanislaus River. Based on the life history timing for steelhead, the slightly higher temperatures in June and September of drier years under the No Action Alternative may increase the likelihood of adverse effects to steelhead rearing in the Stanislaus River; the lower temperatures in October under the No Action Alternative may reduce the likelihood of adverse effects on adult steelhead during their upstream migration.

Changes in Exceedance of Water Temperature Thresholds (Stanislaus River)

Average monthly water temperatures in the Stanislaus River at Orange Blossom Bridge would frequently exceed the temperature threshold (56°F) established for adult steelhead migration under both the No Action Alternative and Second Basis of Comparison during October and November. Under the No Action Alternative, average monthly water temperatures would exceed 56°F about 57 percent of the time in October which is about 28 percent less frequently than under the Second Basis of Comparison (Appendix 6B, Figure B-18-1). In November, average monthly water temperatures would exceed 56°F about 33 percent of the time under the No Action Alternative, which would be about 5 percent more frequently than under the Second Basis of Comparison (Appendix 6B, Figure B-18-2).

From January through May, the temperature threshold at Orange Blossom Bridge is 55°F, which is intended to support steelhead spawning. This threshold would not be exceeded under either the No Action Alternative or Second Basis of Comparison during January or February. From March through May, however, exceedances would occur under both the No action Alternative and Second Basis of Comparison, with the threshold most frequently exceeded (nearly half the time) under the No Action Alternative in May (Appendix 9N). Average monthly water temperatures under the No Action Alternative would exceed the threshold 5 percent more frequently in March, 6 percent more frequently in May, and 17 percent less frequently in April than under the Second Basis of Comparison.

From June through November, the temperature threshold of 65°F established to support steelhead rearing would be exceeded under both the No Action Alternative and Second Basis of Comparison in all months but November, and would exceed the threshold about 16 percent of the time in July under both the No Action Alternative and Second Basis of Comparison. The differences between the No Action Alternative and Second Basis of Comparison range from 1 percent less frequent exceedance in October to 4 percent more frequent exceedance in June under the No Action Alternative.

Average monthly water temperatures also would exceed the threshold (52°F) established for smoltification at Knights Ferry. At Goodwin Dam, about 4 miles upstream of Knights Ferry, average monthly water temperatures under the No Action Alternative would exceed 52°F in March, April, and May about 8 percent, 33 percent, and 63 percent of the time, respectively. Water temperatures under the No Action Alternative would result in exceedances occurring about 1 to 2 percent less frequently during the January through May period. Farther downstream at Orange Blossom Bridge, the temperature threshold for smoltification is higher (57°F) and would be exceeded less frequently. The magnitude of the exceedance also would be less. Average monthly water temperatures under the No Action Alternative and the Second Basis of Comparison would not exceed the threshold during January through March. In April and May, exceedances of 2 percent and 18 percent would occur under the No Action Alternative, which represent a frequency of about 6 percent less than the Second Basis of Comparison in April and about an 8 percent higher frequency in May.

Overall, the differences in exceedance frequency between the No Action Alternative and Second Basis of Comparison would be relatively small, with the exception of substantial differences in the frequency of exceedances in October when the average monthly water temperatures under the No Action Alternative would exceed the threshold for adult steelhead migration about 28 percent less frequently and in April during the spawning period when the exceedance frequency would be about 17 percent less. Given the frequency of exceedance under both the No Action Alternative and Second Basis of Comparison and the generally stressful temperature conditions in the river, the substantial differences (improvements) in October and April under the No Action Alternative suggest that there would be less potential to for adverse effects on steelhead under the No Action Alternative than under the Second Basis of Comparison. Even during months when the differences would be relatively small, the lower frequency of exceedances under the No Action Alternative suggest that there would be less potential to result in adverse effects on steelhead under the No Action Alternative than under the Second Basis of Comparison.

Changes in Delta Hydrodynamics

San Joaquin River-origin steelhead generally move through the Delta during spring; however, there is less information on their timing than there is for Chinook salmon. Thus, hydrodynamics in the entire January through June period have the potential to affect juvenile steelhead. For a description of potential hydrodynamic effects on steelhead, see the descriptions for fall-run Chinook Salmon in the San Joaquin River basin above.

Summary of Effects on Steelhead

The analysis of the effects of the No Action Alternative and Second Basis of Comparison for steelhead relied on the water temperature model output for the rivers at various locations downstream of Goodwin Dam. The temperature model outputs for each of the steelhead life stages suggest that thermal conditions and effects on steelhead generally would be similar under both scenarios, although water temperatures could be somewhat more suitable for steelhead rearing under the No Action Alternative. Water temperatures could be somewhat less suitable during the adult upstream migration period under the No Action relative to the Second Basis of Comparison. This conclusion is supported by the water temperature threshold exceedance analysis that indicated that the water temperature threshold for steelhead migration would be exceeded less frequently in October, but more frequently in November under the No Action Alternative. The water temperature threshold for steelhead spawning would also be exceeded less frequently under the No Action Alternative. The water temperature threshold for steelhead rearing generally would be exceeded more frequently under the No

Action Alternative, while the temperature thresholds for smoltification would be exceeded less frequently in most months.

Implementation of the fish passage program under the No Action Alternative intended to address the limited availability of suitable habitat for steelhead in the Stanislaus River reaches downstream of Goodwin Dam could provide a benefit to steelhead, however, the extent of benefit is uncertain. In addition, the potential effects of the No Action Alternative could be offset by the RPA actions intended to reduce predation risk on steelhead in the Stanislaus River, provide passage to upstream habitat, and to increase the efficiency of the Tracy and Skinner Fish Collection Facilities. The actions to augment spawning gravel in the Stanislaus River under the No Action Alternative also could benefit steelhead.

The numerical model results for effects on steelhead under the No Action Alternative and Second Basis of Comparison do not definitively show distinct differences. However, in consideration of the potentially beneficial effects resulting from the RPA actions under the No Action Alternative that are not included in the numerical models (see Appendix 5A, Section B), the No Action Alternative has a much greater potential to address the long-term sustainability of steelhead than does the Second Basis of Comparison. The No Action Alternative includes provisions for fish passage upstream of New Melones Dam to address long-term temperature increases associated with climate change. Even though the success of fish passage is uncertain, it is concluded that the potential for adverse effects on steelhead under the No Action Alternative would be clearly less than those under the Second Basis of Comparison, principally because the Second Basis of Comparison does not include a strategy to address water temperatures critical to steelhead sustainability over the long term with climate change by 2030.

Reservoir Fishes

The analysis of effects associated with changes in operation on reservoir fishes relied on evaluation of changes in available habitat (reservoir storage) and anticipated changes in black bass nesting success.

As described in Chapter 5, Surface Water Resources and Water Supplies, changes in CVP and SWP water supplies and operations under the No Action Alternative as compared to the Second Basis of Comparison would result in lower Storage levels in New Melones Reservoir under the No Action Alternative as compared to the Second Basis of Comparison, as summarized in Table 5.16, due to increased instream releases to support fish flows under the 2009 NMFS BO.

Storage in New Melones could be reduced up to around 10 percent in some months of some water year types. Additional information related to monthly reservoir elevations is provided in Appendix 5A, CalSim II and DSM2 Modeling. It is anticipated that aquatic habitat within New Melones is not limiting; however, storage volume is an indicator of how much habitat is available to fish species inhabiting these reservoirs. Therefore, the amount of habitat for reservoir fishes could be reduced under the No Action Alternative as compared to the Second Basis of Comparison.

As shown in Appendix 9F, predicted survival in New Melones is higher than in the other reservoirs during May and June. For March, Largemouth Bass and Smallmouth Bass nest survival is predicted to be above 40 percent in all of the years simulated. For April, the likelihood that nest survival of Largemouth Bass and Smallmouth Bass is between 40 and 100 percent would be about 13 percent lower under the No Action Alternative than under the Second Basis of Comparison, but still would be relatively high (around 80 percent). For May, this pattern is reversed with the likelihood of high nest survival being similar under the No Action Alternative and the Second Basis of Comparison. For June, the likelihood of survival being greater than 40 percent for Largemouth Bass and Smallmouth Bass in New Melones is also higher (by about 8 percent) under the No Action Alternative as compared to the Second Basis of Comparison. For Spotted Bass, nest survival from March through June is anticipated to be near 100 percent in every year under both the No Action Alternative and Second Basis of Comparison.

The somewhat lower likelihood of high nesting survival for Largemouth and Smallmouth Bass during April is not expected to adversely affect nesting success because the likelihood of successful nesting would be relatively high. Thus, it is concluded that effects on black bass nesting success would be similar under the No Action Alternative and the Second Basis of Comparison.

Other species

Changes in operations that influence temperature and flow conditions in the Stanislaus River downstream of Goodwin Dam and the San Joaquin River at Vernalis could affect other species such as lampreys, Hardhead, and Striped Bass.

As described above, average monthly water temperatures in the Stanislaus River at Goodwin Dam under the No Action Alternative and Second Basis of Comparison generally would be similar. Downstream at Orange Blossom Bridge, average monthly water temperatures in the November to March period under the No Action Alternative generally would be similar to, although somewhat higher than, under the Second Basis of Comparison, except in April when average monthly water temperatures in all water year types would be lower under the No Action Alternative. This temperature pattern would continue downstream to the confluence with the San Joaquin River, although temperatures would progressively increase, as would the magnitude of difference between the No Action Alternative and Second Basis of Comparison (Appendix 6B, Table B-19-1).

In general, lamprey species can tolerate higher temperatures than salmonids, up to around 72°F during their entire life history. Because lamprey ammocoetes remain in the river for several years, any substantial flow reductions or water temperature increases could result in adverse effects on larval lamprey. Given the relatively minor changes in water temperature and water temperature threshold exceedance, and the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), it is likely that the potential to affect lamprey species in the Stanislaus and San Joaquin rivers would be similar under the No Action Alternative and the Second Basis of Comparison.

In general, Striped Bass and Hardhead also can tolerate higher temperatures than salmonids. Given the relatively minor changes in water temperature and water temperature threshold exceedance, the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), it is likely that the potential to affect Striped Bass and Hardhead in the Stanislaus and San Joaquin rivers would be similar under the No Action Alternative and the Second Basis of Comparison.

9.4.3.2 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 aquatic resource conditions under Alternative 1 are identical to aquatic resource conditions under the Second Basis of Comparison; Alternative 1 is only compared to the No Action Alternative.

9.4.3.2.1 Alternative 1 Compared to the No Action Alternative

Trinity River Region

Coho Salmon

The analysis of effects associated with changes in operation on Coho Salmon was conducted using temperature model outputs for Lewiston Dam to anticipate the likely effects on conditions in the Trinity River downstream of Lewiston Dam for Coho Salmon.

Long-term average monthly water temperatures in the Trinity River at Lewiston Dam under Alternative 1 generally would be similar to the water temperatures that would occur under the No Action Alternative (Appendix 6B, Table B-1-1). Average monthly temperatures under Alternative 1 generally would be similar to those predicted under the No Action Alternative in most water year types, except from November through January in above- and below-normal water years when water temperatures under Alternative 1 could be up to 1.5°F cooler than under the No Action Alternative. In November of critical years water temperatures under Alternative 1 could be as much as 2.4°F warmer than under the No action Alternative (Appendix 6B, Table B-1-1). Average monthly water temperatures generally would be similar (less than 0.5°F differences) under Alternative 1 and the No Action Alternative from July through September, except in September of wet years when temperatures would be slightly (0.7°F) lower under Alternative 1.

The USFWS established a water temperature threshold of 56°F for Coho Salmon spawning in the reach of the Trinity River from Lewiston to the confluence with the North Fork Trinity River from October through December. Although not entirely reflective of water temperatures throughout the reach, the temperature model provides average monthly water temperature outputs for releases from the Lewiston Dam, which may provide perspective on temperature conditions in the reach below. In October and November, average monthly water temperatures under both Alternative 1 and the No Action Alternative would exceed 56°F at Lewiston Dam in some years (Appendix 9N). Under Alternative 1, the threshold would be exceeded about 6 percent of the time in October, about 1 percent less frequently than under the No Action Alternative. In November, both scenarios would result in an exceedance frequency of about 2 percent. There would be no exceedance of the threshold in December under both the Alternative 1 and the No Action Alternative.

Overall, the temperature model outputs for each of the Coho Salmon life stages suggest that the temperature of water released at Lewiston Dam generally would be similar under both scenarios, although the exceedance of water temperature thresholds would be slightly less frequent (1 percent) under Alternative 1. The higher water temperatures in November of critical years (and lower temperatures in December) under Alternative 1 would likely have little effect on Coho Salmon as water temperatures in the Trinity River are typically low during this time period. Given the similarity of the results and the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), Alternative 1 and the No Action Alternative are likely to have similar effects on the Coho Salmon population in the Trinity River.

Spring-run Chinook Salmon

The analysis of effects associated with changes in operation on spring-run Chinook Salmon was conducted using temperature model outputs for Lewiston Dam to anticipate the likely effects on conditions in the Trinity River downstream of Lewiston Dam.

As described above for Coho Salmon, the temperature differences between Alternative 1 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on spring-run Chinook Salmon in the Trinity River. The higher average monthly water temperatures (up to 2.4°F) in November of critical years (and lower temperatures in December) under Alternative 1 would likely have little effect on spring-run Chinook Salmon as water temperatures in the Trinity River are typically low during this time period.

Under both Alternative 1 and the No Action Alternative, average monthly water temperatures in the Trinity River at Lewiston Dam would infrequently (1 percent to 2 percent of the time) exceed 60°F, the threshold for spring-run Chinook Salmon holding. There would be no difference in the frequency of exceedance of the 60°F threshold under Alternative 1 as compared to the No Action Alternative. In September, however, the threshold for spawning (56°F) would be exceeded 11 percent of the time under Alternative 1 which is about 2 percent more frequently than under the No Action Alternative.

Overall, the differences in the frequency of threshold exceedance between Alternative 1 and the No Action Alternative would be relatively minor, although temperature conditions under Alternative 1 could be slightly more likely to result in adverse effects on spring-run Chinook Salmon spawning than under the No Action Alternative because of the increased frequency of exceedance of the 56°F threshold at Lewiston Dam in September.

The majority of spring-run Chinook Salmon in the Trinity River are produced in the South Fork Trinity watershed. Although the water temperatures under Alternative 1 could result in adverse effects on spring-run Chinook Salmon in the Trinity River, these effects would not occur in every year and are not anticipated to be substantial based on the relatively small differences water temperatures under Alternative 1 as compared to the No Action Alternative.

Overall, Alternative 1 is likely to have similar effects on the spring-run Chinook Salmon population in the Trinity River as compared to the No Action Alternative. However, implementation of the Hatchery Management Plan (RPA Action II.6.3) under the No Action Alternative could reduce the impacts of hatchery Chinook Salmon on natural spring-run Chinook Salmon in the Trinity River, and increase the genetic diversity and diversity of run-timing for these stocks relative to Alternative 1. Thus, given the relatively minor changes in water temperature and water temperature threshold exceedance, the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), and the uncertainty of the hatchery benefits, it is concluded that Alternative 1 and the No Action Alternative are likely to have similar effects on the spring-run Chinook Salmon in the Trinity River.

Fall-Run Chinook Salmon

The analysis of effects associated with changes in operation on fall-run Chinook Salmon was conducted using temperature model outputs for Lewiston Dam to anticipate the likely effects on conditions in the Trinity River downstream of Lewiston Dam. In addition, the Reclamation Salmon Mortality Model was used to assess egg mortality.

As described above for Coho Salmon, the temperature differences between Alternative 1 and No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on fall-run Chinook Salmon in the Trinity River. The higher water temperatures (as much as 2.4°F) in November of critical years (and lower temperatures in December) under Alternative 1 would likely have little effect on fall-run Chinook Salmon as water temperatures in the Trinity River are typically low during this time period.

The temperature threshold and months during which it applies for fall-run Chinook Salmon are the same as those for Coho Salmon. Under Alternative 1, the threshold would be exceeded about 6 percent of the time in October, about 1 percent less frequently than under the No Action Alternative. In November, both conditions would result in an exceedance frequency of about 2 percent. There would be no exceedance of the threshold in December under both Alternative 1 and the No Action Alternative. Overall, the differences in the frequency of threshold exceedance between Alternative 1 and the No Action Alternative would be relatively minor. Temperature conditions under the Alternative 1 could be slightly less likely to result in adverse effects on fall-run

Chinook Salmon spawning than under the No Action Alternative because of the reduced frequency of exceedance of the 56°F threshold at Lewiston Dam in October. However, this would occur prior to the peak spawning period for fall-run Chinook Salmon.

The temperatures described above for the Trinity River downstream of Lewiston Dam are reflected in the analysis of egg mortality using the Reclamation salmon mortality model (Appendix 9C). For fall-run Chinook Salmon in the Trinity River, the long-term average egg mortality rate is predicted to be relatively low (around 4 percent), with higher mortality rates (nearly 15 percent) occurring in critical dry years under the No Action Alternative (Appendix 9C, Table B-1-5). Overall, egg mortality under Alternative 1 and the No Action Alternative would be similar in all water year types.

Although the combined analysis based on water temperature suggests that operations under Alternative 1 could be slightly less adverse than under the No Action Alternative, these effects would not occur in every year and are not anticipated to be substantial based on the relatively small differences in water temperatures (and similar egg mortality) between Alternative 1 and the No Action Alternative. In addition, implementation of the Hatchery Management Plan (RPA Action II.6.3) under the No Action Alternative could reduce the impacts of hatchery Chinook Salmon on natural fall-run Chinook Salmon in the Trinity River, and increase the genetic diversity and diversity of run-timing for these stocks relative to Alternative 1.

Overall, given the small differences in the numerical model results and the inherent uncertainty in the temperature model, as well as the potential for offsetting benefits associated with the Hatchery Management Plan, it is concluded that there would be no definitive difference in effects on fall-run Chinook Salmon between Alternative 1 and the No Action Alternative.

Steelhead

The analysis of effects associated with changes in operation on steelhead relied on temperature model outputs for Lewiston Dam to anticipate the likely effects on conditions in the Trinity River downstream of Lewiston Dam.

Temperature differences between Alternative 1 and No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on steelhead in the Trinity River. The higher water temperatures (up to 2.4°F) in November of critical years (and lower temperatures in December) under Alternative 1 would likely have little effect on steelhead as water temperatures in the Trinity River are typically low during this time period.

The temperature threshold and months during which it applies for steelhead are the same as those described for Coho Salmon. Thus, the frequency of average monthly water temperatures in the Trinity River at Lewiston Dam exceeding the threshold of 56°F for steelhead would be the same as those described above for Coho Salmon. Water temperature conditions under Alternative 1 could be less likely to affect steelhead spawning than under the No Action Alternative because of the slightly (1 percent) reduced frequency of exceedance of the 56°F threshold at Lewiston Dam in October. The biological significance of this difference, however, is uncertain.

Although the combined analysis based on water temperature suggests that operations under Alternative 1 could be slightly less adverse than under the No Action Alternative, these effects would not occur in every year and are not anticipated to be substantial based on the relatively small differences in water temperatures between Alternative 1 and the No Action Alternative. Overall, given these small differences in water temperatures and the inherent uncertainty in the temperature model, Alternative 1 and the No Action Alternative are likely to have similar effects on steelhead in the Trinity River.

Green Sturgeon

The analysis of effects associated with changes in operation on Green Sturgeon relied on temperature model outputs for Lewiston Dam to anticipate the likely effects on conditions in the Trinity River downstream of Lewiston Dam.

Green Sturgeon spawn in the lower reaches of the Trinity River during April through June, and water temperatures above about 63°F are believed stressful to embryos (Van Eenennaam et al. 2005). Average monthly water temperature conditions during April through June in the Trinity River at Lewiston Dam under Alternative 1 would be similar to the temperatures under the No Action Alternative and would not exceed 58°F during this period. In addition, water temperatures in the reach of the river where Green Sturgeon spawn are likely controlled by other factors (e.g., ambient air temperatures and tributary inflows) more than water operations at Trinity and Lewiston dams.

Overall, given the similarities between average monthly water temperatures at Lewiston Dam under Alternative 1 and the No Action Alternative, it is likely that water temperature conditions for Green Sturgeon in the Trinity River or lower Klamath River and estuary would be similar under both scenarios.

Reservoir Fishes

The analysis of effects associated with changes in operation on reservoir fishes relied on evaluation of changes in available habitat (reservoir storage) and anticipated changes in black bass nesting success.

Changes in CVP water supplies and operations under Alternative 1 as compared to the No Action Alternative would result in higher reservoir storage in Trinity Lake. Storage in Trinity Lake could increase by up to about 10 percent in some months of some water year types. Additional information related to monthly reservoir elevations is provided in Appendix 5A, CalSim II and DSM2 Modeling.

Using Trinity Lake storage as an indicator of habitat available to fish species inhabiting the reservoir, the amount of habitat for reservoir fishes would not be reduced under Alternative 1 as compared to the No Action Alternative.

As shown in Appendix 9F, nest survival in Trinity Lake is near 100 percent in March and April due to increasing reservoir elevations. For May, the likelihood of survival for Largemouth Bass in Trinity Lake being in the 40 to 100 percent range is slightly (about 2 percent) higher under Alternative 1 as compared to the No Action Alternative. For June, the likelihood of survival being greater than 40 percent for Largemouth Bass is somewhat lower than in May and is slightly lower (about 2 percent) under Alternative 1 as compared to the No Action Alternative. For Spotted Bass, the likelihood of survival being greater than 40 percent would be 100 percent in May under both Alternative 1 and the No Action Alternative. For June, Spotted Bass survival in Trinity Lake would be less than for May due to greater daily reductions in water surface elevation. The likelihood of survival being greater than 40 percent would be similar (near 100 percent) under Alternative 1 and the No Action Alternative.

Overall, the comparison of storage and the analysis of nesting suggest that effects of Alternative 1 on reservoir fishes would be similar to those under the No Action Alternative.

Pacific Lamprey

Little information is available on factors that influence populations of Pacific Lamprey in the Trinity River, but they are likely affected by many of the same factors as salmon and steelhead because of the parallels in their life cycles. On average, the temperature of water released at Lewiston Dam under Alternative 1 generally would be similar to (less than 0.5°F differences) to those under the No Action Alternative. Given the similarities in water temperatures, it is likely that the effects on Pacific Lamprey would be similar under Alternative 1 and the No Action Alternative. This conclusion likely applies to other species of lamprey that inhabit the Trinity and lower Klamath rivers (e.g., River Lamprey).

Eulachon

It is unclear whether this species has been extirpated from the Klamath River. Given that the highest increases in flow under Alternative 1 would be less than 10 percent in the Trinity River (Appendix 5A), with a smaller relative change in the lower Klamath River and Klamath River estuary, and that water temperatures in the Klamath River are unlikely to be affected by changes upstream at Lewiston Dam, it is likely that Alternative 1 would have a similar potential to influence Eulachon in the Klamath River as the No Action Alternative.

Sacramento River System

Winter-run Chinook Salmon

Changes in operations that influence temperature and flow conditions in the Sacramento River downstream of Keswick Dam could affect winter-run Chinook Salmon. The following describes those changes and their potential effects.

Changes in Water Temperature

Long-term average monthly water temperature in the Sacramento River at Keswick Dam under Alternative 1 would generally be similar to (less than 0.5°F difference) to water temperatures under the No Action Alternative. An exception is during September and October of critical dry years when water temperatures could be up to 1.1°F and 0.8°F lower, respectively, under Alternative 1 as compared to the No Action Alternative and up to 1°F warmer in September of wetter years in some water year types(up to 0.3°F) (Appendix 6B, Table B-5-1). A similar pattern of changes in temperature generally would be exhibited downstream at Ball's Ferry, Jelly's Ferry, and Bend Bridge, with average monthly temperatures differences between the scenarios progressively decreasing, except in September (up to 2.8°F warmer at Bend Bridge) during wetter years under Alternative 1 (Appendix 6B, Table B-8-1).

Overall, the temperature differences between Alternative 1 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have similar effects on winter-run Chinook Salmon in the Sacramento River. Spawning for winter-run Chinook Salmon in the Sacramento River takes place from mid-April to mid-August with incubation occurring over the same time period and extending into October. The somewhat lower water temperatures in September and October of critical dry years under the No Action Alternative could reduce the likelihood of adverse effects on winter-run Chinook Salmon egg incubation and fry rearing during this water year type. However, the increased water temperatures during this time period under Alternative 1 in wetter years could increase the likelihood of adverse effects on egg incubation relative to the No Action Alternative.

Changes in Exceedances of Water Temperature Thresholds

With the exception of April, average monthly water temperatures from April to September under both Alternative 1 and the No Action Alternative would show exceedances of the water temperature threshold of 56°F established in the Sacramento River at Ball's Ferry for winter-run Chinook Salmon spawning and egg incubation (Appendix 9N). Under Alternative 1, the temperature threshold generally would be exceeded less frequently than under the No Action Alternative (by about 1 percent to 3 percent) in the April through August period, with the temperature threshold in September exceeded in 52 percent of the simulated years about 10 percent more frequently under Alternative 1 than the No Action Alternative (42 percent). Farther downstream at Bend Bridge, the frequency of exceedances would increase, with exceedances under both Alternative 1 and the No Action as Alternative as high as about 90 percent in some months. Under Alternative 1, temperature exceedances generally would be less frequent (by up to 8 percent) than under the No Action Alternative, with the exception of September, when threshold exceedances under Alternative 1 would be about 29 percent more frequent.

Overall, there would be substantial differences in the frequency of threshold exceedance between Alternative 1 and the No Action Alternative, particularly in September. Temperature conditions under Alternative 1 would reduce the likelihood of adverse effects on winter-run Chinook Salmon egg incubation than under the No Action Alternative because of the reduced frequency of exceedance of the 56°F threshold from April through August. However, the substantial increase in the frequency of exceedance in September under Alternative 1 may increase the likelihood of adverse effects on winter-run Chinook Salmon egg incubation during this limited portion of the spawning and egg incubation period.

Changes in Egg Mortality

The temperatures described above for the Sacramento River downstream of Keswick Dam are reflected in the analysis of egg mortality using the Reclamation salmon mortality model (Appendix 9C). For winter-run Chinook Salmon in the Sacramento River, the long-term average egg mortality rate is predicted to be relatively low (around 4 percent), with higher mortality rates (exceeding 20 percent) occurring in critical dry years under Alternative 1. In critical dry years the average egg mortality rate would be 5.4 percent lower under Alternative 1 than under the No Action Alternative (Appendix 9C, Table B-4). Overall, winter-run Chinook Salmon egg mortality in the Sacramento River under Alternative 1 and the No Action Alternative would be similar, except in critical dry water years.

Changes in Weighted Usable Area

As described above for the assessment methodology, Weighted Usable Area (WUA) is a function of flow, but the relationship is not linear due to differences in depths and velocities present in the wetted channel at different flows. Because the combination of depths, velocities, and substrates preferred by species and life stages varies, WUA values at a given flow can differ substantially for the life stages evaluated.

As an indicator of the amount of suitable spawning habitat for winter-run Chinook Salmon between Keswick Dam and Battle Creek, modeling results indicate that, in general, there would be similar amounts of spawning habitat available from May through September under Alternative 1 and the No Action Alternative (Appendix 9E).

Modeling results indicate that, in general, there would be similar amounts of suitable fry rearing habitat available from June through October under Alternative 1 and the No Action Alternative (Appendix 9E).

Similar to the results for fry rearing WUA, modeling results indicate that there would be similar amounts of suitable juvenile rearing habitat available during the juvenile rearing period from September through August under Alternative 1 and the No Action Alternative (Appendix 9E).

Changes in SALMOD Output

SALMOD results indicate that potential juvenile production under Alternative 1 would be the similar to the No Action Alternative (Appendix 9D, Table B-4-1).

Changes in Delta Passage Model Output

The Delta Passage Model predicted similar estimates of annual Delta survival across the 81 water year time period for winter-run Chinook Salmon between Alternative 1 and the No Action Alternative (Appendix 9J). Median Delta survival would be 0.352 for Alternative 1 and 0.349 for the No Action Alternative.

Changes in Oncorhynchus Bayesian Analysis Output

Escapement of winter-run Chinook Salmon and Delta survival was modeled by the Oncorhynchus Bayesian Analysis (OBAN) model for winter-run Chinook salmon. Escapement was generally lower under Alternative 1 as compared to the No Action Alternative (Appendix 9I). The median abundance under Alternative 1 was lower in 19 of the 22 years of simulation (1971 to 2002), and there was typically greater than a 25 percent chance that Alternative 1 values would be lower than under the No Action Alternative. Median delta survival was approximately 12 percent lower under Alternative 1 as compared to the No Action Alternative. However, the probability intervals indicated that no difference between scenarios was a likely outcome.

Changes in Interactive Object-Oriented Simulation Output

The IOS model predicted similar adult escapement trajectories for winter-run Chinook Salmon between Alternative 1 and the No Action Alternative across the 81 water years (Appendix 9H). Under Alternative 1 median adult escapement was 4,042 and under the No Action Alternative, median escapement was 3,935.

Similar to adult escapement, the IOS model predicted similar egg survival time histories for winter-run Chinook Salmon between Alternative 1 and the No Action Alternative across the 81 water years (Appendix 9H). Under Alternative 1 median egg survival was 0.987 and under the No Action Alternative median egg survival was 0.990.

Changes in Delta Hydrodynamics

Winter-run Chinook Salmon smolts are most abundant in the Delta during January, February and March. On the Sacramento River near the confluence of Georgiana Slough, the median proportion of positive velocities under Alternative 1 was indistinguishable from the No Action Alternative (Appendix 9K).

Changes in Junction Entrainment

Entrainment at Georgiana Slough was similar under both Alternative 1 and No Action Alternative during January, February and March when winter-run Chinook Salmon smolts are most abundant in the Delta (Appendix 9L).

Changes in Salvage

Salvage of Sacramento River-origin Chinook Salmon is predicted to be greater under Alternative 1 relative to No Action Alternative in every month (Appendix 9M). Winter-run Chinook Salmon smolts migrating through the Delta would be most susceptible in the months of January, February and March. Predicted values in January and February indicated a moderate increase in the proportion of fish salvaged under Alternative 1 relative to the No Action Alternative.

Summary of Effects on Winter-Run Chinook Salmon

The multiple model and analysis outputs described above characterize the anticipated conditions for winter-run Chinook Salmon and their response to change under Alternative 1 as compared to the No Action Alternative. For the purpose of analyzing effects on winter-run Chinook Salmon and developing conclusions, greater reliance was placed on the outputs from the two life cycle models, IOS and OBAN because they each integrate the available information to produce single estimates of winter-run Chinook Salmon escapement. The output from IOS indicated that winter-run Chinook Salmon escapement would be similar under both scenarios, whereas the OBAN results indicated that escapement under Alternative 1 would be lower than under the No Action Alternative, although there would be some chance (less than a 25 percent) that escapement under the Alternative 1 could be greater than the No Action Alternative.

These model results suggest that effects on winter-run Chinook Salmon would be similar under both scenarios, with a small likelihood that winter-run Chinook Salmon escapement would be lower under Alternative 1 than under the No Action Alternative. This potential distinction between the two scenarios, however, may be offset or reversed by the benefits of implementation of fish passage under the No Action Alternative intended to address the limited availability of suitable habitat for winter-run Chinook Salmon in the Sacramento River reaches downstream of Keswick Dam. This potential beneficial effect and its magnitude would depend on the success of the fish passage program. In addition, RPA actions intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities could improve the overall salvage survival of winter-run Chinook Salmon.

Overall, the quantitative results from the numerical models suggest that operation under the Alternative 1 would be more likely to result in adverse effects on winter-run Chinook Salmon than would the No Action Alternative. In addition, the potentially beneficial effects resulting from the RPA actions under the No Action Alternative that are not included in the numerical models (see Appendix 5A, Section B) suggest that the No Action Alternative has a much greater potential to address the long-term sustainability of winter-run Chinook Salmon than does the Alternative 1. It is concluded that the potential for adverse effects on winter-run Chinook Salmon under Alternative 1 would be greater than those under the No Action Alternative, principally because Alternative 1 does not include fish passage to address water temperatures critical to winter-run Chinook Salmon sustainability over the long term with climate change by 2030.

Spring-run Chinook Salmon

Changes in operations that influence temperature and flow conditions in the Sacramento River downstream of Keswick Dam, Clear Creek downstream of Whiskeytown Dam, and Feather River downstream of Oroville Dam could affect spring-run Chinook Salmon. The following describes those changes and their potential effects.

Changes in Water Temperature

Changes in water temperature that could affect spring-run Chinook Salmon could occur in the Sacramento River, Clear Creek, and Feather River. The following describes temperature conditions in those water bodies.

Sacramento River

Long-term average monthly water temperature in the Sacramento River at Keswick Dam under Alternative 1 would generally be similar (less than 0.5°F difference) to water temperatures under the No Action Alternative An exception is during September and October of critical dry years when water temperatures could be up to 1.1°F and 0.8°F lower, respectively, under Alternative 1 as compared to the No Action Alternative and up to 1°F warmer in September of wetter years (Appendix 6B, Table B-5-1). A similar pattern of changes in temperature generally would be exhibited downstream at Ball's Ferry, Jelly's Ferry, Bend Bridge and Red Bluff, with average monthly temperature differences between scenarios progressively decreasing, except in September (up to 3.2°F warmer at Red Bluff) during wetter years (Appendix 6B, Table B-9-1).

Overall, the temperature differences between Alternative 1 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on spring-run Chinook Salmon in the Sacramento River. The slightly lower water temperatures from October to December under Alternative 1 would likely have little effect on spring-run Chinook Salmon as water temperatures in the Sacramento River below Keswick Dam are typically low during this time period. The somewhat higher water temperatures in September of wetter years may increase the likelihood of adverse effects on spring-run Chinook Salmon spawning, although the decreased temperatures in September of critical dry years under Alternative 1 may reduce the likelihood of adverse effects on spring-run Chinook Salmon spawning in this water year type. There would be little difference in potential effects on spring-run Chinook Salmon holding over the summer due to the similar water temperatures during this time period under Alternative 1 and the No Action Alternative.

Clear Creek

Average monthly water temperatures in Clear Creek at Igo under Alternative 1 relative to the No Action Alternative are generally predicted to be similar (less than 0.5°F differences) from September through April and June through August from September through April and June through August (Appendix 6B, Table B-3-1). Average monthly water temperatures during May under Alternative 1 could be higher by up to 0.8°F than under the No Action Alternative. Overall, thermal conditions for spring-run Chinook Salmon in Clear Creek would be similar under Alternative 1 and the No Action Alternative.

Feather River

Average monthly water temperature in the Feather River in the low flow channel generally were predicted to be similar (less than 0.5°F differences) under Alternative 1 and the No Action Alternative, except during November and December when average monthly water temperatures could be up to 1.4°F lower in some water year types (Appendix 6B, Table B-20-1). Average monthly water temperatures in September under Alternative 1 could be up to 1.3°F warmer than under the No Action Alternative in wetter years. Although temperatures in the river would become progressively higher in the downstream directions, the differences between Alternative 1 and No Action Alternative would exhibit a similar pattern at the downstream locations (Robinson Riffle and Gridley Bridge), with water temperature differences between Alternative 1 and the No Action Alternative generally decreasing in most water year types. However, water temperatures from July to September under Alternative 1 were predicted to be somewhat (0.7°F to 1.6°F) warmer on average and up to 4.0°F warmer at the confluence with the Sacramento River in wetter years (Appendix 6B, Table B-23-1).

Overall, the temperature differences in the Feather River between Alternative 1 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on spring-run Chinook Salmon in the Feather River. The slightly lower water temperatures in November and December under Alternative 1 would likely have little effect on spring-run Chinook Salmon as water temperatures in the Feather River are typically low during this time period. The somewhat higher water temperatures in September of wetter years may increase the likelihood of adverse effects on spring-run Chinook Salmon spawning, although the decreased temperatures in September of critical dry years under Alternative 1 may reduce the likelihood of adverse effects on spring-run Chinook Salmon spawning in this water year type. There would be little difference in potential effects on spring-run Chinook Salmon holding over the summer due to the similar water temperatures during this time period under Alternative 1 and the No Action Alternative.

Changes in Exceedances of Water Temperature Thresholds

Changes in water temperature could result in the exceedance of established water temperature thresholds for spring-run Chinook Salmon in the Sacramento River, Clear Creek, and Feather River. The following describes the extent of water temperature threshold exceedances for each of those water bodies.

Sacramento River

Average monthly water temperatures under both Alternative 1 and No Action Alternative would show exceedances of the water temperature threshold of 56°F established in the Sacramento River at Red Bluff for spring-run Chinook Salmon (egg incubation) in October, November, and again in April. The exceedances would occur at the greatest frequency in October (79 percent of the time under Alternative 1); under Alternative 1 the water temperature threshold would be exceeded less frequently in November (7 percent of the time under Alternative 1) and not exceeded at all from December through March (Appendix 9N). As water temperatures warm in the spring, the thresholds would be exceeded in April by 15 percent under Alternative 1. In the months when the greatest frequency of exceedances occur (October, November, and April), model results generally indicate less frequent exceedances (by up to 4 percent in October) under Alternative 1 than under the No Action Alternative. Temperature conditions in the Sacramento River under Alternative 1 could be less likely to affect spring-run Chinook Salmon egg incubation than under the No Action Alternative because of the decreased frequency of exceedance of the 56°F threshold in October, November, and April. However, this difference may be partially offset if water temperature management and fish passage measures associated with 2009 NMFS BO RPA under the No Action Alternative are successful.

Clear Creek

Average monthly water temperatures under both Alternative 1 and No Action Alternative would not exceed the water temperature threshold of 60°F established in Clear Creek at Igo for spring-run Chinook Salmon pre-spawning and rearing in June through August. However, water temperatures under Alternative 1 and the No Action Alternative would exceed the water temperature threshold of 56°F established for spawning in September and October about 10 percent to 15 percent of the time (Appendix 9N). Water temperatures under Alternative 1 could exceed the threshold about 3 percent less frequently than under the No Action Alternative in September and about 2 percent less frequently in October (Appendix 9N). Temperature conditions in Clear Creek under Alternative 1 could be less likely to affect spring-run Chinook Salmon spawning than under the No Action Alternative because of the decreased frequency of exceedance of the 56°F threshold in September and October. However, this difference may be partially offset if the thermal stress reduction measures associated with 2009 NMFS BO RPA Action I.1.5 under the No Action Alternative are successful in improving water temperatures in Clear Creek.

Feather River

Average monthly water temperatures under both Alternative 1 and the No Action Alternative would exceed the water temperature threshold of 56°F established in the Feather River at Robinson Riffle for spring-run Chinook Salmon egg incubation and rearing during some months, particularly in October and November, and March and April, when temperature thresholds could be exceeded frequently (Appendix 9N). The frequency of exceedance was highest in October, a month in which average monthly water could get as high as about 68°F. However, water temperatures under Alternative 1 would exceed the spawning temperature threshold about 1 percent less frequently than under the No Action Alternative in October, November, and December, and about 2 percent more frequently in March.

The established water temperature threshold of 63°F for rearing during May through August would be exceeded often under both Alternative 1 and the No Action Alternative in May and June, but not at all in July and August. Water temperatures under Alternative 1 would exceed the rearing temperature threshold about 9 percent less frequently than under the No Action Alternative in May. Temperature conditions in the Feather River under Alternative 1 could be less likely to affect spring-run Chinook Salmon spawning and rearing than under the No Action Alternative because of the decreased frequency of exceedance of the water temperature thresholds.

Changes in Egg Mortality

These temperature differences described above are reflected in the analysis of egg mortality using the Reclamation salmon mortality model (Appendix 9C). For spring-run Chinook Salmon in the Sacramento River, the long-term average egg mortality rate is predicted to be relatively high (exceeding 20 percent), with high mortality rates (exceeding 70 percent) occurring in critical dry years. In critical dry years the average egg mortality rate under Alternative 1is predicted to be 10.4 percent lower than under the No Action Alternative (Appendix 9C, Table B-3). Overall, spring-run Chinook Salmon egg mortality in the Sacramento River under Alternative 1 and the No Action Alternative would be similar, except in critical dry water years.

Changes in Weighted Usable Area

Weighted usable area curves are available for spring-run Chinook Salmon in Clear Creek. As described above, flows in Clear Creek downstream of Whiskeytown Dam are not anticipated to differ under Alternative 1 relative to the No Action Alternative except in May due to the release of spring attraction flows in accordance with the 2009 NMFS BO under the No Action Alternative. Therefore, there would be no change in the amount of potentially suitable spawning and rearing habitat for spring-run Chinook Salmon (as indexed by WUA) available under Alternative 1 as compared to the No Action Alternative.

Changes in SALMOD Output

SALMOD results indicate that potential spring-run juvenile production would be similar under Alternative 1 and the No Action Alternative except that production under Alternative 1 could be 12 percent higher than under the No Action Alternative in critical dry years (Appendix 9D, Table B-3-1).

Changes in Delta Passage Model Output

The Delta Passage Model predicted similar estimates of annual Delta survival across the 81 water year time period for spring-run Chinook Salmon between Alternative 1 and the No Action Alternative (Appendix 9J). Median Delta survival was 0.286 for Alternative 1 and 0.296 for the No Action Alternative.

Changes in Delta Hydrodynamics

Spring-run Chinook Salmon are most abundant in the Delta from March through May. Near the junction of Georgiana Slough, the median percent of time that velocity was positive was similar in March, April, and May for both scenarios. In Old River upstream of the facilities, the median percent of time with positive velocity was similar in March, slightly lower in April, and moderately lower in May under Alternative 1 relative to the No Action Alternative (Appendix 9K). In Old River downstream of the facilities the median percent of time with positive velocity was slightly lower in March and increasingly lower in April and May under Alternative 1 relative to No Action Alternative.

Changes in Junction Entrainment

Entrainment at Georgiana Slough was similar under both Alternative 1 and No Action Alternative during March, April and May when spring run are most abundant in the Delta (Appendix 9L).

Changes in Salvage

Salvage of Sacramento River-origin Chinook Salmon is predicted to be higher under Alternative 1 relative to No Action Alternative in every month (Appendix 9M). Spring-run smolts migrating through the Delta would be most susceptible in the months of March April and May. Predicted values in April and May indicated a substantially larger fraction of fish salvaged under Alternative 1. Predicted salvage was more similar in March but still higher under Alternative 1 than under the No Action Alternative.

Summary of Effects on Spring-Run Chinook Salmon

The multiple model and analysis outputs described above characterize the anticipated conditions for spring-run Chinook Salmon and their response to change under Alternative 1 and the No Action Alternative. For the purpose of analyzing effects on spring-run Chinook Salmon in the Sacramento River, greater reliance was placed on the outputs from the SALMOD model because it integrates the available information on temperature and flows to produce estimates of mortality for each life stage and an overall, integrated estimate of potential spring-run Chinook Salmon juvenile production. The output from SALMOD indicated that spring-run Chinook Salmon production in the Sacramento River would be similar under Alternative 1 and the No Action Alternative, although production under Alternative 1 could be over 10 percent greater than under the No Action Alterative in critical dry years. The analyses attempting to assess the effects on routing, entrainment, and salvage of juvenile salmonids in the Delta suggest that salvage (as an indicator of potential losses of juvenile salmon at the export facilities) of Sacramento River-origin Chinook Salmon is predicted to be higher under Alternative 1 relative to No Action Alternative in every month.

In Clear Creek and the Feather River, the analysis of the effects of Alternative 1 and the No Action Alternative for spring-run Chinook Salmon relied on output from the WUA analysis and water temperature output for Clear Creek at Igo, and in the Feather River low flow channel and downstream of the Thermalito complex. The WUA analysis suggests that there would be little difference in the availability of spawning and rearing habitat in Clear Creek. The temperature model outputs suggest that thermal conditions and effects on each of the spring-run Chinook Salmon life stages generally would be similar under both scenarios in Clear Creek and the Feather River, although water temperatures could be somewhat more suitable for spring-run Chinook Salmon holding and spawning/egg incubation in the Feather River under Alternative 1. This conclusion is supported by the water temperature threshold exceedance analysis that indicated that water temperature thresholds for spawning and egg incubation would be exceeded slightly less frequently under Alternative 1 than under the No Action Alternative in Clear Creek and the Feather River. The water temperature threshold for rearing spring-run Chinook Salmon would also be exceeded slightly less frequently in the Feather River under Alternative 1. Because of the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), the slightly greater likelihood of exceeding water temperature thresholds under Alternative 1 could increase the potential for adverse effects on the spring-run Chinook Salmon populations in the Feather River. Given the similarity of the results, Alternative 1 and the No Action Alternative are likely to have similar effects on the spring-run Chinook Salmon population in Clear Creek.

These model results suggest that overall, effects on spring-run Chinook Salmon could be slightly less adverse under Alternative 1 than the No Action Alternative. This potential distinction between the two scenarios, however, may be partially offset by the benefits of implementation of fish passage under the No Action Alternative intended to address the limited availability of suitable habitat for spring-run Chinook Salmon in the Sacramento River reaches downstream of Keswick Dam. This potential beneficial effect and its magnitude would depend on the success of the fish passage program. In addition, RPA actions intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities could improve the overall salvage survival of spring-run Chinook Salmon under the No Action Alternative.

Thus, it is concluded that the potential for adverse effects on spring-run Chinook Salmon under Alternative 1 would be greater than under the No Action Alternative, principally because Alternative 1 does not include a strategy to address water temperatures critical to spring-run Chinook Salmon sustainability over the long term with climate change by 2030.

Fall-Run Chinook Salmon

Changes in operations that influence temperature and flow conditions in the Sacramento River downstream of Keswick Dam, Clear Creek downstream of Whiskeytown Dam, Feather River downstream of Oroville Dam and American River downstream of Nimbus could affect fall-run Chinook Salmon. The following describes those changes and their potential effects.

Changes in Water Temperature

Changes in water temperature could affect fall-run Chinook Salmon in the Sacramento, Feather, and American rivers, and Clear Creek. The following describes temperature conditions in those water bodies.

Sacramento River

Long-term average monthly water temperature in the Sacramento River at Keswick Dam under Alternative 1 would generally be similar (less than 0.5°F difference) to water temperatures under the No Action Alternative. An exception is during September and October of critical dry years when water temperatures could be up to 1.1°F and 0.8°F lower, respectively, under Alternative 1 as compared to the No Action Alternative and up to 1°F warmer in September of wetter years (Appendix 6B). A similar pattern in temperature differences generally would be exhibited at downstream locations along the Sacramento River (i.e., Ball’s Ferry Jelly’s Ferry, Bend Bridge, Red Bluff, Hamilton City, and Knights Landing), with temperature differences between scenarios at Knights Landing progressively increasing (up to 0.9°F cooler) in June and up to 4.6°F warmer in September during wetter years under Alternative 1 relative to the No Action Alternative.

Overall, the temperature differences between Alternative 1 and the o Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on fall-run Chinook Salmon in the Sacramento River. The somewhat higher water temperatures in September of wetter years may increase the likelihood of adverse effects on early spawning fall-run Chinook Salmon under Alternative 1, although the reduced water temperatures in September of critical dry years under Alternative 1 may decrease the likelihood of adverse effects on fall-run Chinook Salmon spawning in this water year type.

Clear Creek

Average monthly water temperatures in Clear Creek at Igo under Alternative 1 relative to the No Action Alternative are generally predicted to be similar (less than 0.5°F) from September through April and June through August (Appendix 6B, Table B-3-1). Average monthly water temperatures during May under Alternative 1 would be higher by up to 0.8°F than under the No Action Alternative. Average monthly temperatures at the confluence with the Sacramento River would exhibit a similar pattern, although temperatures in the creek would be slightly higher in general.

Under Alternative 1, temperature conditions at Igo would be similar to temperature conditions under the No Action Alternative. However, these temperature outputs represent conditions at Igo, a location upstream of most fall-run Chinook Salmon spawning and rearing. Water temperatures where most fall-run Chinook Salmon inhabit the creek would be somewhat higher as indicated by average monthly temperatures at the confluence with the Sacramento River, although these temperatures would be similar under Alternative 1 and the No Action Alternative. Overall, thermal conditions for fall-run Chinook Salmon in Clear Creek would be similar under Alternative 1 and the No Action Alternative.

Feather River

Average monthly water temperature in the Feather River in the low flow channel generally were predicted to be similar (less than 0.5°F differences) under Alternative 1 and the No Action Alternative, except during November and December when average monthly water temperatures could be up to 1.4°F lower in some water year types (Appendix 6B, Table B-20-1). Average monthly water temperatures in September under Alternative 1 could be up to 1.3°F warmer than under the No Action Alternative in wetter years. Although temperatures in the river would become progressively higher in the downstream directions, the differences between Alternative 1 and No Action Alternative would exhibit a similar pattern at the downstream locations (Robinson Riffle and Gridley Bridge), with water temperatures differences between Alternative 1 and the No Action Alternative generally decreasing in most water year types. However, water temperatures under Alternative 1 were predicted to be somewhat (0.7°F to 1.6°F) warmer on average and up to 4.0°F warmer at the confluence with the Sacramento River from July to September in wetter years (Appendix 6B, Table B-23-1).

Overall, the temperature differences in the Feather River between Alternative 1 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on fall-run Chinook Salmon in the Feather River. The slightly lower water temperatures in November and December under Alternative 1 would likely have little effect on fall-run Chinook Salmon as water temperatures in the Feather River are typically low during this time period. The somewhat higher water temperatures in September of wetter years may increase the likelihood of adverse effects on early spawning fall-run Chinook Salmon, although the decreased temperatures in September of critical dry years under Alternative 1 may reduce the likelihood of adverse effects on fall-run Chinook Salmon spawning in this water year type.

American River

Long-term average monthly water temperatures in the American River at Nimbus Dam under Alternative 1 generally would be similar (differences less than 0.5°F) to the No Action Alternative, with the exception of during June and August, when temperatures under Alternative 1 could be as much as 0.9°F lower in below normal years (Appendix 6B, Table B-12-1). This pattern generally would persist downstream to Watt Avenue and the mouth, although temperatures under Alternative 1 would be up to 1.6°F and 2.0°F lower, respectively, than under the No Action Alternative in June. In addition, average monthly water temperatures at the mouth generally would be higher under Alternative 1 than the No Action Alternative in September of wetter years when water temperatures under Alternative 1 could be up to 1.7°F warmer (Appendix 6B, Table B-14-1).

Overall, the temperature differences in the American River between Alternative 1 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on fall-run Chinook Salmon in the American River. The slightly lower water temperatures in June and August in some water year types under Alternative 1 may decrease the likelihood of adverse effects on fall-run Chinook Salmon rearing in the American River if they are present. The slightly higher water temperatures during September under Alternative 1 would have little effect on fall-run Chinook Salmon spawning in the American River because most spawning occurs later in November.

Changes in Exceedances of Water Temperature Thresholds

Changes in water temperature could result in the exceedance of water temperatures that are protective of fall-run Chinook Salmon in the Sacramento River, Clear Creek, Feather River, and American River. The following describes the extent of those exceedances for each of those water bodies.

Sacramento River

Average monthly water temperatures under both Alternative 1 and the No Action Alternative indicate exceedances of the water temperature threshold of 56°F established in the Sacramento River at Red Bluff for Chinook Salmon spawning and egg incubation in October, November, and again in April. There would be no exceedances of the threshold from December to March under both Alternative 1 and the No Action Alternative. In the months when the greatest frequency of exceedances occur (October, November, and April), model results generally indicate less frequent exceedances (by up to 4 percent in October) under Alternative 1 than under the No Action Alternative. Temperature conditions in the Sacramento River under Alternative 1 could be less likely to affect fall-run Chinook Salmon spawning and egg incubation than under the No Action Alternative because of the reduced frequency of exceedance of the 56°F threshold in October, November, and April. However, this difference may be partially offset if water temperature management and fish passage measures associated with 2009 NMFS BO RPA under the No Action Alternative are successful.

Clear Creek

Fall-run Chinook Salmon spawning in lower Clear Creek typically occurs during October through December (USFWS 2015). Average monthly water temperatures at Igo during this period generally fall below 56°F, except in October. Under Alternative 1, the 56°F threshold would be exceeded in October about 10 percent of the time as compared to 12 percent under the No Action Alternative (Appendix 9N). At the confluence with the Sacramento River, average monthly water temperatures in October would be warmer, with the 56°F threshold exceeded slightly less frequently under Alternative 1 compared to the No Action Alternative (Appendix 6B, Figure B-4-1). During November and December, average monthly water temperatures generally would remain below 56°F at both locations (Appendix 6B, Figure B-4-2 and B-4-3). Temperature conditions in Clear Creek under Alternative 1 could be less likely to affect fall-run Chinook Salmon spawning and egg incubation than under the No Action Alternative because of the reduced frequency of exceedance of the 56°F threshold in October.

For fall-run Chinook Salmon rearing (January through August), the average monthly temperatures at Igo would likely remain below the 60°F rearing threshold in all months. Downstream at the mouth of Clear Creek, average monthly water temperatures would exceed the 60°F threshold often during the summer, but the frequency of exceedance would be similar under Alternative 1 and the No Action Alternative (Appendix 6B). Temperature conditions for fall-run Chinook Salmon rearing in Clear Creek would be similar under Alternative 1 and the No Action Alternative.

Feather River

Average monthly water temperatures under both Alternative 1 and No Action Alternative would exceed the water temperature threshold of 56°F established in the Feather River at Gridley Bridge for fall-run Chinook Salmon spawning and egg incubation during some months, particularly in October, November, March, and April, when this temperature threshold would be exceeded frequently (Appendix 6B, Table B-22-4). The frequency of exceedance would be greatest in October, when average monthly temperatures under both Alternative 1 and the No Action Alternative would be above the threshold in nearly every year. The magnitude of the exceedances would be high as well, with average monthly temperatures in October reaching about 68°F. Similarly, the threshold would be exceeded under both Alternative 1 and the No Action Alternative about

85 percent of the time in April. The differences between Alternative 1 and the No Action Alternative, however, would be relatively small, with water temperatures under Alternative 1 generally exceeding the spawning temperature threshold about 1-2 percent less frequently than under the No Action Alternative during the October through April period. Temperature conditions in the Feather River under Alternative 1 could be less likely to affect fall-run Chinook Salmon spawning and egg incubation than under the No Action Alternative because of the reduced frequency of exceedance of the 56°F threshold from October through April.

Changes in Egg Mortality

Water temperatures influence the viability of incubating fall-run Chinook Salmon eggs. The following describes the differences in egg mortality for the Sacramento, Feather, and American rivers.

Sacramento River

For fall-run Chinook Salmon in the Sacramento River, the long-term average egg mortality rate is predicted to be around 17 percent, with higher mortality rates (in excess of 35 percent) occurring in critical dry years under Alternative 1. Predicted egg mortality would similar under Alternative 1 and the No Action Alternative in all water year types (Appendix 9C, Table B-1).

Feather River

For fall-run Chinook Salmon in the Feather River, the long-term average egg mortality rate is predicted to be relatively low (around 7 percent), with higher mortality rates (around 17 percent) occurring in critical dry years under Alternative 1. Predicted egg mortality would similar under Alternative 1 and the No Action Alternative in all water year types (Appendix 9C, Table B-7).

American River

For fall-run Chinook Salmon in the American River, the predicted long-term average egg mortality rate is predicted to range from approximately 22 to 25 percent in all water year types under Alternative 1. The predicted egg mortality rate would similar under Alternative 1 and the No Action Alternative (Appendix 9C, Table B-6).

Changes in Weighted Usable Area

Weighted usable area, which is influenced by flow, is a measure of habitat suitability. The following describes changes in WUA for fall-run Chinook Salmon in the Sacramento, Feather, and American rivers and Clear Creek.

Sacramento River

As an indicator of the amount of suitable spawning habitat for fall-run Chinook Salmon between Keswick Dam and Battle Creek, modeling results indicate that, in general, there would be greater amounts of spawning habitat available in September and November under Alternative 1 as compared to the No Action Alternative. Fall-run spawning WUA would be similar in October and December, under Alternative 1 and the No Action Alternative (Appendix 9E, Table C-11-4). The increase in long-term average spawning WUA during September (prior to the peak spawning period) under Alternative 1 would be relatively large (more than

20 percent) and around 6 percent higher in November. November is during the peak spawning period for fall-run Chinook Salmon in the Sacramento River. Results for the reach from Battle Creek to Deer Creek show the same pattern for changes in WUA for spawning fall-run Chinook Salmon between Alternative 1 and the No Action Alternative (Appendix 9E, Table C-10-4). Overall, spawning habitat availability would be somewhat higher under Alternative 1 relative to the No Action Alternative.

Modeling results indicate that, in general, the amount of suitable fry rearing habitat available from December to March under Alternative 1 would be similar to the amount of fry rearing habitat available under the No Action Alternative (Appendix 9E, Table C-12-4).

Similar to the results for fry rearing WUA, modeling results indicate that, there would be similar amounts of suitable juvenile rearing habitat available during the juvenile rearing period from February to June under Alternative 1 and the No Action Alternative (Appendix 9E, Table C-13-4).

Clear Creek

As described above, flows in Clear Creek downstream of Whiskeytown Dam are not anticipated to differ under Alternative 1 relative to the No Action Alternative except in May due to the release of spring attraction flows in accordance with the 2009 NMFS BO under the No Action Alternative. Therefore, there would be no change in the amount of potentially suitable spawning and rearing habitat for fall-run Chinook Salmon (as indexed by WUA) available under Alternative 1 as compared to the No Action Alternative.

Feather River

As described above, Flows in the low flow channel of the Feather River are not anticipated to differ under Alternative 1 relative to the No Action Alternative. Therefore, there would be no change in the amount of potentially suitable spawning habitat for fall-run Chinook Salmon (as indexed by WUA) available under Alternative 1 as compared to the No Action Alternative. The majority of spawning activity by fall-run Chinook Salmon in the Feather River occurs in this reach with a lesser amount of spawning occurring downstream of the Thermalito Complex.

Modeling results indicate that, in general, there would be greater amounts of spawning habitat available in September under Alternative 1 as compared to the No Action Alternative; fall-run Chinook Salmon spawning WUA would be similar in October and November (the peak spawning months) and in December (after the peak spawning period) for fall-run Chinook Salmon in this reach (Appendix 9E, Table C-24-4). The increase in long-term average spawning WUA during September (prior to the peak spawning period) under Alternative 1 would be relatively large (more than 15 percent). Overall, spawning habitat availability would be similar under Alternative 1 and the No Action Alternative.

American River

Modeling results indicate that, in general, there would be similar amounts of spawning habitat available for fall-run Chinook Salmon in the American River from October through December under Alternative 1 as compared to the No Action Alternative (Appendix 9E, Table C-25-4).

Changes in SALMOD Output

SALMOD results indicate that pre-spawning mortality of fall-run Chinook Salmon eggs would be approximately 16 percent lower under Alternative 1, primarily due to reduced summer temperatures. Flow-related fall-run Chinook Salmon egg mortality would be increased by 8 percent under Alternative 1 compared to the No Action Alternative. Conversely, temperature-related egg mortality would be 11 percent lower under Alternative 1 (Appendix 9D, Table B-1-4). Flow (habitat)-related fry mortality would be similar under Alternative 1 and the No Action Alternative. Temperature-related juvenile mortality would be approximately 21 percent lower under Alternative 1, while flow (habitat)-related mortality would be similar under Alternative 1 and the No Action Alternative. Overall, potential fall-run juvenile production would be similar under Alternative 1 and the No Action Alternative, but up to 12 percent greater than under the No Action Alternative in critical dry years (Appendix 9D, Table B-1-1).

Changes in Delta Passage Model Output

The Delta Passage Model predicted similar estimates of annual Delta survival across the 81 water year time period for fall-run between Alternative 1 and the No Action Alternative (Appendix 9J). Median Delta survival was 0.245 for Alternative 1 and 0.248 for the No Action Alternative.

Changes in Delta Hydrodynamics

Fall-run Chinook Salmon smolts are most abundant in the Delta during the months of April, May and June. At the junction of Georgiana Slough and the Sacramento River, median percent of time with positive velocity was similar under both Alternative 1 and No Action Alternative in the months of April, May and June (Appendix 9K). Near the confluence of the San Joaquin River and the Mokelumne River, the median proportion of positive velocities was slightly lower under Alternative 1 relative to No Action Alternative in April and May and similar in June. In Old River downstream of the facilities, the median proportion of positive velocities was substantially lower in April and May under Alternative 1 relative to No Action Alternative but became more similar in June (Appendix 9K). In Old River upstream of the facilities, the median proportion of positive velocities was slightly to moderately lower for Alternative 1 relative to No Action Alternative in April and May, respectively and slightly higher in June (Appendix 9K). On the San Joaquin River downstream of the Head of Old River, the median proportion of positive velocities was slightly to moderately higher under Alternative 1 relative to No Action Alternative in April and May, respectively, whereas the values were similar in June (Appendix 9K).

Changes in Junction Entrainment

Entrainment at Georgiana Slough was similar under both Alternative 1 and the No Action Alternative in most months but was slightly higher under Alternative 1 in the month of June (Appendix 9L). Median entrainment probabilities at the Head of Old River were much lower under Alternative 1 relative to the No Action Alternative during April and May. The median entrainment probability was similar under both alternatives in the month of June. At the Turner Cut junction, median entrainment probabilities under Alternative 1 were slightly higher than under the No Action Alternative in June. During April and May, median entrainment probabilities were more divergent with moderately higher values for Alternative 1 relative to No Action Alternative. Overall, entrainment was slightly lower at the Columbia Cut junction relative to Turner Cut but patterns of entrainment between the two alternatives were similar. Patterns in entrainment probabilities at the Middle River and Old River junctions were similar to those observed at Columbia and Turner Cut junctions.

Changes in Salvage

Salvage of Sacramento River-origin Chinook Salmon is predicted to be greater under Alternative 1 relative to No Action Alternative in every month (Appendix 9M). Fall-run smolts migrating through the Delta would be most susceptible in the months of April, May and June. Predicted values in April and May indicated a substantially increased fraction of fish salvaged under Alternative 1 relative to No Action Alternative. Predicted salvage was more similar in March but still higher under Alternative 1.

Summary of Effects on Fall-Run Chinook Salmon

The multiple model and analysis outputs described above characterize the anticipated conditions for fall-run Chinook Salmon and their response to change under Alternative 1 and the No Action Alternative. For the purpose of analyzing effects on fall-run Chinook Salmon in the Sacramento River, greater reliance was placed on the outputs from the SALMOD model because it integrates the available information on temperature and flows to produce estimates of mortality for each life stage and an overall, integrated estimate of potential fall-run Chinook Salmon juvenile production. The output from SALMOD indicated that fall-run Chinook Salmon production would be similar in most water year types under Alternative 1 than under the No Action Alternative, and up to 12 percent greater than under the No Action Alternative in critical dry years.

The analyses attempting to assess the effects on routing, entrainment, and salvage of juvenile salmonids in the Delta suggest that salvage (as an indicator of potential losses of juvenile salmon at the export facilities) of Sacramento River-origin Chinook Salmon is predicted to be higher under Alternative 1 relative to No Action Alternative in every month.

In Clear Creek and the Feather and American rivers, the analysis of the effects of Alternative 1 and the No Action Alternative for fall-run Chinook Salmon relied on the WUA analysis for habitat and water temperature model output for the rivers at various locations downstream of the CVP and SWP facilities. The WUA analysis indicated that the availability of spawning and rearing habitat in Clear Creek and spawning habitat in the Feather and American rivers would be similar under Alternative 1 and the No Action Alternative. The temperature model outputs for each of the fall-run Chinook Salmon life stages suggest that thermal conditions and effects on fall-run Chinook Salmon in all of these streams generally would be similar under both scenarios. The water temperature threshold exceedance analysis that indicated that the water temperature thresholds for fall-run Chinook Salmon spawning and egg incubation would be exceeded slightly less frequently in the Feather River and Clear Creek under Alternative 1 and could reduce the potential for adverse effects on the fall-run Chinook Salmon populations in Clear Creek and the Feather River. Results of the analysis using Reclamation’s salmon mortality model indicate that there would be little difference in fall-run Chinook Salmon egg mortality under Alternative 1 and the No Action Alternative.

These model results suggest that overall, effects on fall-run Chinook Salmon could be slightly less adverse under Alternative 1 than the No Action Alternative, with a small likelihood that fall-run Chinook Salmon production would be higher under Alternative 1 due to increased production potential in critical dry years. This potential distinction between the two scenarios, however, may be partially balanced by the benefits of implementation of fish passage under the No Action Alternative intended to address the limited availability of suitable habitat for winter-run and spring-run Chinook Salmon in the Sacramento River reaches downstream of Keswick Dam. This potential benefit, however, would only apply if passage is provided for adult fall-run Chinook Salmon that allows access to additional habitat. In addition, RPA actions under the No Action Alternative intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities could improve the overall salvage survival of fall-run Chinook Salmon.

The results of the numerical models suggest that Alternative 1 is less likely to result in adverse effects on fall-run Chinook Salmon than the No Action Alternative. However, discerning a meaningful difference between these two scenarios based on the quantitative results is not possible because of the similarity in results (generally differences less than 5 percent) and the inherent uncertainty of the models. In addition, adverse effects of the No Action Alternative could be balanced by the potentially beneficial effects resulting from the RPA actions evaluated qualitatively for the No Action Alternative. Overall, given the small differences in the numerical model results and the inherent uncertainty in the temperature model, as well as the potential for benefits associated with the RPA actions under the No Action Alternative, it is concluded that there would be no definitive difference in effects on fall-run Chinook Salmon between Alternative 1 and the No Action Alternative.

Late Fall-Run Chinook Salmon

Changes in operations that influence temperature and flow conditions in the Sacramento River downstream of Keswick Dam could affect late fall-run Chinook Salmon. The following describes those changes and their potential effects.

Changes in Water Temperature

Long-term average monthly water temperature in the Sacramento River at Keswick Dam under Alternative 1 would generally be similar (less than 0.5°F difference) to water temperatures under the No Action Alternative An exception is during September and October of critical dry years when water temperatures could be up to 1.1°F and 0.8°F lower, respectively, under Alternative 1 as compared to the No Action Alternative and up to 1°F warmer in September of wetter years (Appendix 6B, Table 5-5-1). A similar pattern in temperature differences generally would be exhibited at downstream locations along the Sacramento River (i.e., Ball's Ferry Jelly's Ferry, Bend Bridge, Red Bluff, Hamilton City, and Knights Landing), with temperature differences between scenarios in June at Knights Landing progressively increasing (up to 0.9°F cooler) in June and up to 4.6°F warmer in September during wetter years under Alternative 1 relative to the No Action Alternative.

Overall, the temperature differences between Alternative 1 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on late fall-run Chinook Salmon in the Sacramento River. The likelihood of adverse effects on late fall-run Chinook Salmon spawning and egg incubation would be similar under Alternative 1 and the No Action Alternative due to similar water temperatures during the January to May time period. Because late fall-run Chinook Salmon have an extended rearing period, the similar water temperatures during the summer under Alternative 1 and the No Action Alternative would have similar effects on rearing fry and juvenile late fall-run Chinook Salmon in the Sacramento River. The higher water temperatures under Alternative 1 in September of wetter years may increase the likelihood of adverse effects on fry and juvenile late fall-run Chinook Salmon in the Sacramento River during this limited time period.

Changes in Exceedances of Water Temperature Thresholds

Average monthly water temperatures under both Alternative 1 and the No Action Alternative indicate exceedances of the water temperature threshold of 56°F established in the Sacramento River at Red Bluff for Chinook Salmon spawning and egg incubation in October, November, and again in April. There would be no exceedances of the threshold from December to March under both Alternative 1 and the No Action Alternative. In April, model results indicate that water temperatures under Alternative 1 would exceed the threshold about 2 percent less frequently than under the No Action Alternative. Temperature conditions in the Sacramento River under Alternative 1 could be slightly less likely to result in adverse effects on late fall-run Chinook Salmon spawning and egg incubation than under the No Action Alternative because of the reduced frequency of exceedance of the 56°F threshold in April.

Changes in Egg Mortality

For late fall-run Chinook Salmon in the Sacramento River, the long-term average egg mortality rate is predicted to range from approximately 2 to nearly 5 percent in all water year types under Alternative 1. Overall, egg mortality would be similar under Alternative 1and the No Action Alternative (Appendix 9C, Table B-2).

Changes in Weighted Usable Area

Modeling results indicate that there would be similar amounts of spawning habitat available for late fall-run Chinook Salmon in the Sacramento River from January through April under Alternative 1 and the No Action Alternative (Appendix 9E, Table C-14-4). Modeling results also indicate that there would be similar amounts of suitable late fall-run Chinook Salmon fry rearing habitat available from April to June under Alternative 1 and the No Action Alternative (Appendix 9E, Table C-15-4).

A substantial fraction of late fall run Chinook Salmon juveniles oversummer in the Sacramento River before emigrating, which allows them to avoid predation through both their larger size and greater swimming ability. One implication of this life history strategy is that rearing habitat is most likely the limiting factor for late-fall-run Chinook Salmon, especially if availability of cool water determines the downstream extent of spawning habitat for late-fall-run salmon. Modeling results indicate that, there would generally be similar amounts of suitable juvenile rearing habitat available from December through August under Alternative 1 and the No Action Alternative. There could be an increase in the amount of late fall-run Chinook Salmon juvenile rearing WUA in September and November of up to 15 percent (Appendix 9E, Table C-16-4). Overall, late fall-run juvenile rearing habitat availability would be similar under Alternative 1 and the No Action Alternative.

Changes in SALMOD Output

SALMOD results indicate that potential juvenile production would be similar under Alternative 1 and the No Action Alternative (Appendix 9D, Table B-2-1).

Changes in Delta Passage Model Output

For late fall-run Chinook Salmon, through-Delta survival was predicted to be slightly lower under Alternative 1 relative to the No Action Alternative for all 81 years simulated by the Delta Passage Model (Appendix 9J). Median Delta survival across all years was 0.199 for Alternative 1 and 0.244 for the No Action Alternative.

Changes in Delta Hydrodynamics

The late fall run Chinook migration period overlaps with winter-run. See the section on hydrodynamic analysis for winter run Chinook Salmon for potential effects on late fall-run Chinook Salmon.

Changes in Junction Entrainment

Entrainment probabilities for late fall-run Chinook Salmon are assumed to mimic that of winter-run Chinook Salmon due to the overlap in timing. See the section on winter-run Chinook Salmon entrainment for potential effects on late fall-run Chinook Salmon.

Changes in Salvage

Salvage of late fall-run Chinook Salmon is assumed to mimic that of winter-run Chinook Salmon due to the overlap in timing. See the section on winter-run Chinook Salmon entrainment for potential effects on late fall-run Chinook Salmon.

Summary of Effects on Late Fall-Run Chinook Salmon

The multiple model and analysis outputs described above characterize the anticipated conditions for late fall-run Chinook Salmon and their response to change under Alternative 1 and the No Action Alternative. For the purpose of analyzing effects on late fall-run Chinook Salmon and developing conclusions, greater reliance was placed on the outputs from the SALMOD model because it integrates the available information on temperature and flows to produce estimates of mortality for each life stage and an overall, integrated estimate of potential fall-run Chinook Salmon juvenile production. The output from SALMOD indicated that late fall-run Chinook Salmon production would be similar under Alternative 1 and the No Action Alternative. The analyses attempting to assess the effects on routing, entrainment, and salvage of juvenile salmonids in the Delta suggest that salvage (as an indicator of potential losses of juvenile salmon at the export facilities) of Sacramento River-origin Chinook Salmon is predicted to be higher under Alternative 1 relative to No Action Alternative in every month. Actions under the No Action Alternative intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities could improve the overall salvage survival of late fall-run Chinook Salmon.

Although survival in the Delta may be lower, given the similarity in the SALMOD outputs, it is likely that Alternative 1 and the No Action Alternative would have similar effects on fall-run Chinook Salmon.

Steelhead

Changes in operations that influence temperature and flow conditions that could affect steelhead. The following describes those changes and their potential effects.

Changes in Water Temperature

Changes in water temperature could affect steelhead in the Sacramento, Feather, and American rivers, and Clear Creek. The following describes temperature conditions in those water bodies.

Sacramento River

Long-term average monthly water temperature in the Sacramento River at Keswick Dam under Alternative 1 would generally be similar (less than 0.5°F difference) to water temperatures under the No Action Alternative An exception is during September and October of critical dry years when water temperatures could be up to 1.1°F and 0.8°F lower, respectively, under Alternative 1 as compared to the No Action Alternative and up to 1°F warmer in September of wetter years (Appendix 6B, Table 5-5-1). A similar pattern of changes in temperature generally would be exhibited downstream at Ball’s Ferry, Jelly’s

Ferry, Bend Bridge and Red Bluff, with average monthly temperature differences between scenarios progressively decreasing, except in September (up to a 3.2°F warmer at Red Bluff) during wetter years (Appendix 6B, Table B-9-1).

Overall, the temperature differences between Alternative 1 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on steelhead in the Sacramento River. Based on the life history timing for steelhead, the slightly lower water temperatures in September and October of drier years under Alternative 1 may reduce the likelihood of adverse effects on steelhead adults migrating upstream in the Sacramento River. The higher water temperatures in September of wetter years under Alternative 1 may increase the likelihood of adverse effects on steelhead migration compared to the No Action Alternative.

Clear Creek

Average monthly water temperatures in Clear Creek at Igo under Alternative 1 are generally predicted to be similar to (less than 0.5°F differences) water temperatures under the No Action Alternative from September through April and June through August (Appendix 6B, Table B-3-1). Average monthly water temperatures during May under Alternative 1 could be higher by up to 0.8°F than under the No Action Alternative in all water year types. Overall, thermal conditions for steelhead in Clear Creek would be similar under Alternative 1 and the No Action Alternative.

Feather River

Average monthly water temperature in the Feather River in the low flow channel generally were predicted to be similar (less than 0.5°F differences) under Alternative 1 and the No Action Alternative, except during November and December when average monthly water temperatures could be up to 1.4°F lower in some water year types (Appendix 6B, Table B-20-1). Average monthly water temperatures in September under Alternative 1 could be up to 1.3°F warmer than under the No Action Alternative in wetter years. Although temperatures in the river generally become progressively higher in the downstream direction, the differences between Alternative 1 and the No Action Alternative exhibit a similar pattern at the downstream locations (Robinson Riffle and Gridley Bridge), with water temperature differences between Alternative 1 and the No Action Alternative generally decreasing in most water year types. Water temperatures under Alternative 1 are predicted to be somewhat (0.7°F to 1.6°F) warmer on average and up to 4.0°F warmer at the confluence with Sacramento River from July to September in wetter years than under the No Action Alternative.

Overall, the temperature differences in the Feather River between Alternative 1 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on steelhead in the Feather River. The slightly lower water temperatures in November and December under Alternative 1 would likely have little effect on adult steelhead migration as water temperatures in the Feather River are typically low during this time period. The somewhat higher water temperatures in September of wetter years may increase the likelihood of adverse effects on adult steelhead migrating upstream and juveniles rearing in the Feather River, although the decreased temperatures in September of critical dry years under Alternative 1 may decrease the likelihood of adverse effects on migrating and rearing steelhead in this water year type.

American River

Average monthly water temperatures in the American River at Nimbus Dam under Alternative 1 generally would be similar (differences less than 0.5°F) to the No Action Alternative, with the exception of during June and August, when temperatures under Alternative 1 could be as much as 0.9°F lower in below normal years. This pattern generally would persist downstream to Watt Avenue and the mouth, although temperatures under Alternative 1 would be up to 1.6°F and 2.0°F lower, respectively, than under the No Action Alternative in June. In addition, average monthly water temperatures at the mouth generally would be higher under Alternative 1 than the No Action Alternative in September of wetter years when water temperatures under Alternative 1 could be up to 1.7°F warmer.

Overall, the temperature differences between Alternative 1 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on steelhead in the American River. The slightly cooler water temperatures in June and August under Alternative 1 may reduce the likelihood of adverse effects on steelhead rearing in the American River compared to the No Action Alternative.

Changes in Exceedances of Water Temperature Thresholds

Changes in water temperature could result in the exceedance of established water temperature thresholds for steelhead in the Sacramento River, Clear Creek, and Feather River. The following describes the extent of those exceedance for each of those streams.

Sacramento River

Steelhead spawning in the mainstem Sacramento River generally occurs in the upper reaches from Keswick Dam downstream to near Balls Ferry, with most spawning concentrated near Redding. Most steelhead, however, spawn in tributaries to the Sacramento River. Spawning generally takes place in the January through March period when water temperatures in the river generally do not exceed 52°F under either Alternative 1 or the No Action Alternative. While there are no established temperature thresholds for steelhead rearing in the mainstem Sacramento River, average monthly temperatures when fry and juvenile steelhead are in the river would generally remain below 56°F at Balls Ferry except in August and September when this water temperature would be exceeded 30 to 40 percent of the time under both the No Action Alternative and Second Basis of Comparison. However, water temperatures in the Sacramento River at Balls Ferry would exceed 56°F about 10 percent more often in September under Alternative 1. Overall, thermal conditions for steelhead in the Sacramento River would be similar under Alternative 1 and the No Action Alternative.

Clear Creek

While there are no established temperature thresholds for steelhead spawning in Clear Creek, average monthly water temperatures in the river generally would not exceed 48°F during the spawning period (December to April) under Alternative 1 and the No Action Alternative. Similarly, while there are no established temperature thresholds for steelhead rearing in Clear Creek, average monthly temperatures in most months of the year would not exceed 56°F at Igo under both alternatives. Overall, thermal conditions for steelhead in Clear Creek would be similar under Alternative 1 and the No Action Alternative.

Feather River

Average monthly water temperatures under both Alternative 1 and the No Action Alternative would on occasion exceed the water temperature threshold of 56°F established in the Feather River at Robinson Riffle for steelhead spawning and incubation during some months, particularly in October and November, and March and April, when temperature thresholds could be exceeded frequently (Appendix 9N). There would be a 1 percent exceedance of the 56°F threshold in December under the No Action Alternative and no exceedances of the 56°F threshold from December through February under Alternative 1. However, the differences in the frequency of exceedance between Alternative 1 and No Action Alternative during March and April would be relatively small with water temperatures under Alternative 1 exceeding the threshold about 2 percent more frequently in March (20 percent) and the same exceedance frequency (75 percent) as the No Action Alternative in April.

The established water temperature threshold of 63°F for rearing from May through August would be exceeded often under both Alternative 1 and the No Action Alternative in May and June, but not at all in July and August. Water temperatures under Alternative 1 would exceed the rearing temperature threshold about 9 percent less frequently than under the No Action Alternative in May, but no more frequently in June. Temperature conditions in the Feather River under Alternative 1 could be less likely to affect steelhead spawning and rearing than under the No Action Alternative because of the reduced frequency of exceedance of the 56°F spawning threshold in March and the increased frequency of exceedance of the 63°F rearing threshold in May.

American River

In the American River, the water temperature threshold for steelhead rearing (May through October) is 65°F at the Watt Avenue Bridge. Average monthly water temperatures would exceed this threshold often under both Alternative 1 and No Action Alternative, especially in the July through September period when the threshold is exceeded nearly all of the time. In addition, the magnitude of the exceedance would be high, with average monthly water temperatures sometimes higher than 76°F. The differences in exceedance frequency between Alternative 1 and No Action Alternative, however, would be relatively small and only occur in June (1 percent more frequent exceedance under Alternative 1), and in September, when average monthly water temperatures under Alternative 1 would exceed 65°F about 7 percent more frequently than under the No Action Alternative. Temperature conditions in the American River under Alternative 1 could be more likely to result in adverse effects on steelhead rearing than under the No Action Alternative because of the increased frequency of exceedance of the 65°F rearing threshold.

Changes in Weighted Usable Area

The following describes changes in WUA for steelhead in the Sacramento, Feather, and American rivers and Clear Creek.

Sacramento River

Modeling results indicate that, in general, there would be similar amounts of suitable steelhead spawning habitat available from December through March under Alternative 1 and the No Action Alternative (Appendix 9E, Table C-20-4).

Clear Creek

As described above, flows in Clear Creek downstream of Whiskeytown Dam are not anticipated to differ under Alternative 1 relative to the No Action Alternative except in May due to the release of spring attraction flows in accordance with the 2009 NMFS BO under the No Action Alternative. Therefore, there would be no change in the amount of potentially suitable spawning and rearing habitat for steelhead (as indexed by WUA) available under Alternative 1 as compared to the No Action Alternative.

Feather River

Flows in the low flow channel of the Feather River are not anticipated to differ under Alternative 1 relative to the No Action Alternative. Therefore, there would be no change in the amount of potentially suitable spawning habitat for steelhead (as indexed by WUA) available under Alternative 1 as compared to the No Action Alternative. The majority of spawning activity by steelhead in the Feather River occurs in this reach with a lesser amount of spawning occurring downstream of the Thermalito Complex.

Modeling results indicate that, in general, there would be similar amounts of spawning habitat for steelhead in the Feather River downstream of Thermalito available from December through April under Alternative 1 and the No Action Alternative (Appendix 9E, Table C-22-4).

American River

Modeling results indicate that, in general, there would be similar amounts of spawning habitat for steelhead in the American River downstream of Nimbus Dam available from December through April under Alternative 1 and the No Action Alternative.

Summary of Effects on Steelhead

The multiple model and analysis outputs described above characterize the anticipated conditions for steelhead and their response to change under Alternative 1 and the No Action Alternative. The analysis of the effects of Alternative 1 and the No Action Alternative for steelhead relied on the WUA analysis for habitat and water temperature model output for the rivers at various locations downstream of the CVP and SWP facilities.

The WUA analysis indicated that the availability of steelhead spawning and rearing habitat in Clear Creek and steelhead spawning habitat in the Sacramento, Feather and American rivers would be similar under Alternative 1 and the No Action Alternative. The temperature model outputs for each of the steelhead life stages suggest that thermal conditions and effects on steelhead in all of these streams generally would be similar under both scenarios. This conclusion is supported by the water temperature threshold exceedance analysis that indicated that the water temperature thresholds for steelhead spawning and egg incubation would be exceeded less frequently in the Feather River under Alternative 1. The water temperature threshold for steelhead rearing would also be exceeded less frequently in the Feather River and could reduce the potential for adverse effects on the steelhead population in the Feather River.

The numerical model results suggest that overall, effects on steelhead could be slightly less adverse under Alternative 1 than the No Action Alternative, particularly in the Feather River. Implementation of the fish passage program under the No Action Alternative intended to address the limited availability of suitable habitat for steelhead in the Sacramento River reaches downstream of Keswick Dam and in the American River could provide a benefit to Central Valley steelhead in the Sacramento and American rivers. This is particularly important in light of anticipated increases in water temperature associated with climate change in 2030. In addition to fish passage, preparation and implementation of an HGMP for steelhead at the Nimbus Fish Hatchery and actions under the No Action Alternative intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities could benefit steelhead under the No Action Alternative in comparison to Alternative 1. Thus, on balance and over the long term, the adverse effects on steelhead under Alternative 1 would be greater than those under the No Action Alternative.

Green Sturgeon

The effects on Green Sturgeon were analyzed by comparing changes in water temperature and the frequency of temperature threshold exceedance between Alternative 1 and the No Action Alternative. In addition, potential effects on Green Sturgeon during the Delta portion of their life cycle were evaluated based on changes in Delta outflow. The effects are described and summarized below.

Changes in Water Temperature

The effects of Alternative 1 compared to the No Action Alternative on Green Sturgeon were analyzed based on water temperature model outputs and comparisons of the frequency of water temperature threshold exceedances in the Sacramento and Feather rivers.

Sacramento River

As described previously, long-term average monthly water temperature in the Sacramento River at Keswick Dam under Alternative 1 would generally be similar (less than 0.5°F difference) to water temperatures under the No Action

Alternative An exception is during September and October of critical dry years when water temperatures could be up to 1.1°F and 0.8°F lower, respectively, under Alternative 1 as compared to the No Action Alternative and up to 1°F warmer in September of wetter years (Appendix 6B). A similar pattern in temperature differences generally would be exhibited at downstream locations along the Sacramento River (i.e., Ball's Ferry Jelly's Ferry, Bend Bridge, Red Bluff, Hamilton City, and Knights Landing), with temperature differences between scenarios at Knights Landing progressively increasing (up to 0.9°F cooler) in June and up to 4.6°F warmer in September during wetter years under Alternative 1 relative to the No Action Alternative.

Overall, the temperature differences between Alternative 1 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on Green Sturgeon. Increased temperatures in September are likely not to be lethal, but may increase growth of juvenile green sturgeon if food was not limiting.

Feather River

Average monthly water temperature in the Feather River in the low flow channel generally were predicted to be similar (less than 0.5°F differences) under Alternative 1 and the No Action Alternative, except during November and December when average monthly water temperatures would be up to 1.4°F lower in some water year types (Appendix 6B, Table B-20-1). Average monthly water temperatures in September under Alternative 1 could be up to 1.3°F warmer than under the No Action Alternative in wetter years.

Although temperatures in the river would become progressively higher in the downstream directions, the differences between Alternative 1 and the No Action Alternative would exhibit a similar pattern at the downstream locations (Robinson Riffle and Gridley Bridge), with temperatures differences between Alternative 1 and the No Action Alternative generally decreasing in most water year types. However, water temperatures under Alternative 1 were predicted to be somewhat (0.7°F to 1.6°F) warmer on average and up to 4.0°F warmer at the confluence with the Sacramento River from July to September in wetter years (Appendix 6B, Table B-23-1).

Overall, the temperature differences between Alternative 1 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on Green Sturgeon in the Feather River.

Changes in Exceedances of Water Temperature Thresholds

Changes in water temperature could result in the exceedance of established water temperature thresholds for Green Sturgeon in the Sacramento and Feather rivers. The following describes the extent of those exceedance for each of those rivers.

Sacramento River

Average monthly water temperatures in the Sacramento River at Bend Bridge under both Alternative 1 and the No Action Alternative would exceed the water temperature threshold of 63°F established for Green Sturgeon larval rearing in

August and September, with exceedances under Alternative 1 occurring about 6 percent of the time in August and about 10 percent of the time in September. This is 1 to 2 percent less frequent than under the No Action Alternative. Average monthly water temperatures at Bend Bridge could exceed the threshold by up to 10 degrees (reaching 73°F) during this period. Temperature conditions in the Sacramento River under Alternative 1 could be less likely to result in adverse effects on Green Sturgeon rearing than under the No Action Alternative because of the reduced frequency of exceedance of the 63°F threshold in August and September.

Feather River

Average monthly water temperatures in the Feather River at Gridley Bridge under both Alternative 1 and No Action Alternative would exceed the water temperature threshold of 64°F established for Green Sturgeon spawning, incubation, and rearing in May, June, and September; no exceedances under either scenarios would occur in July and August. The frequency of exceedances would be high, with water temperatures under both Alternative 1 and No Action Alternative exceeding the threshold in June nearly 100 percent of the time. The magnitude of the exceedance also would be substantial, with average monthly water temperatures higher than 72°F in June, and higher than 75°F in July and August. Water temperatures under Alternative 1 would exceed the threshold during May about 9 percent less frequently than the No Action Alternative and about 35 percent more frequently in September. Temperature conditions in the Feather River under Alternative 1 could be less likely to result in adverse effects on Green Sturgeon rearing than under the No Action Alternative because of the reduced frequency of exceedance of the 64°F threshold in May. The increase in exceedance frequency in September under Alternative 1 may have little effect on rearing Green Sturgeon as many juvenile sturgeon may have migrated downstream to the lower Sacramento River and Delta by this time.

Changes in Delta Outflow

As described in Appendix 9P, mean (March to July) Delta outflow was used an indicator of potential year class strength and the likelihood of producing a strong year class of sturgeon. The median value over the 82-year CalSim II modeling period of mean (March to July) Delta outflow was predicted to be 12 percent lower under Alternative 1 than under the No Action Alternative. In addition, the likelihood of mean (March to July) Delta outflow exceeding the threshold of 50,000 cfs was the same under both alternatives.

Summary of Effects on Green Sturgeon

The temperature model outputs for the Sacramento and Feather rivers suggest that thermal conditions and effects on Green Sturgeon in the Sacramento and Feather rivers generally would be slightly less adverse under Alternative 1. This conclusion is supported by the water temperature threshold exceedance analysis that indicated that the water temperature thresholds for Green Sturgeon spawning, incubation, and rearing would be exceeded less frequently under Alternative 1 in the Sacramento River. The water temperature threshold for Green Sturgeon spawning, incubation, and rearing would also be exceeded less frequently during some months in the Feather River, but would be exceeded more frequently in September under Alternative 1 and could reduce the potential for adverse effects on Green Sturgeon in the Sacramento and Feather rivers relative to the No Action Alternative. The analysis based on Delta outflows suggests that Alternative 1 provides lower mean (March to July) outflows which could result in weaker year classes of juvenile sturgeon relative to the No Action Alternative. In addition, actions under the No Action Alternative intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities could improve the overall salvage survival of green sturgeon. However, early life stage survival in the natal rivers is crucial in development of a strong year class. Therefore, based primarily on the analysis of water temperatures, Alternative 1 could be less likely to result in adverse effects on Green Sturgeon than the No Action Alternative.

White Sturgeon

Changes in water temperature conditions in the Sacramento River would be the same as those described above for Green Sturgeon in the Sacramento River. Overall, the temperature differences between Alternative 1 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on White Sturgeon in the Sacramento River.

The water temperature threshold established for White Sturgeon spawning and egg incubation in the Sacramento River at Hamilton City is 61°F from March through June. Although there would be no exceedances of the threshold in March and April, water temperatures under both Alternative 1 and No Action Alternative would exceed this threshold in May and June. The average monthly water temperatures in May under Alternative 1 would exceed this threshold about 49 percent of the time (about 6 percent less frequently than under the No Action Alternative). In June, the average monthly water temperature under Alternative 1 would exceed the threshold about 74 percent of the time (about 13 percent less frequently than under the No Action Alternative). Average monthly water temperatures during May and June under Alternative 1 would as high as about 64°F, which is below the 68°F threshold considered lethal for White Sturgeon eggs. Temperature conditions in the Sacramento River under Alternative 1 could be less likely to result in adverse effects on White Sturgeon rearing than under the No Action Alternative because of the reduced frequency of exceedance of the 61°F threshold in May and June.

Changes in Delta outflows would be the same as those described above for Green Sturgeon. Mean (March to July) Delta outflow was predicted to be 12 percent lower under Alternative 1 than under the No Action Alternative. In addition, the likelihood of mean (March to July) Delta outflow exceeding the threshold of 50,000 cfs was the same under both alternatives.

Overall, the temperature model outputs suggest that thermal conditions and effects on White Sturgeon in the Sacramento River generally would be slightly less adverse under Alternative 1. The analysis based on Delta outflows suggests that Alternative 1 provides lower mean (March to July) outflows which could result in weaker year classes of juvenile Green Sturgeon relative to the No Action Alternative. However, early life stage survival in the natal rivers is crucial in development of a strong year class. Therefore, based primarily on the analysis of water temperatures, Alternative 1 could be less likely to result in adverse effects on White Sturgeon than the No Action Alternative.

Delta Smelt

The potential for effects on Delta Smelt resulting from Alternative 1 as compared to the No Action Alternative were analyzed using changes in proportional entrainment and fall abiotic habitat index values.

As described in Appendix 9G, a proportional entrainment regression model (based on Kimmerer 2008, 2011) was used to simulate adult Delta Smelt entrainment, as influenced by OMR flow in December through March. Results indicate that the percentage of entrainment of migrating and spawning adult Delta Smelt under Alternative 1 would be 9 percent (long term average percent entrainment). Percent entrainment of adult Delta Smelt under Alternative 1 would be similar to results under the No Action Alternative.

As described in Appendix 9G, a proportional entrainment regression model (based on Kimmerer 2008) was used to simulate larval and early juvenile Delta Smelt entrainment, as influenced by OMR flow and location of X2 in March through June. Results indicate that the percentage of entrainment of larval and early juvenile Delta Smelt under Alternative 1 would be 15.5 percent, long-term average, and highest entrainment of 23.6 percent under Critical water year conditions. Percent entrainment of larval and early juvenile Delta Smelt under Alternative 1 would be higher than results under the No Action Alternative, by up to 9.4 percent. Under the No Action Alternative, the long term average percent entrainment would be 8.6 percent, and highest entrainment would occur under Critical water year conditions, at 19.3 percent.

The predicted location of Fall X2 position (in September through December) is used as an indicator of fall abiotic habitat index for Delta Smelt. Feyrer et al. (2010) used X2 location as an indicator of the extent of habitat available with suitable salinity for the rearing of older juvenile delta smelt. Feyrer et al. (2010) concluded that when X2 is located downstream (west) of the confluence of the Sacramento and San Joaquin Rivers, at a distance of 70 to 80 km from the Golden Gate Bridge, there is a larger area of suitable habitat. The overlap of the low salinity zone (or X2) with the Suisun Bay/Marsh results in a two-fold increase in the habitat index (Feyrer et al. 2010). The average September through December X2 position in km was used to evaluate the fall abiotic habitat availability for delta smelt under the Alternatives. X2 values simulated in the CalSim II model for each Alternative were averaged over September through December, and compared.

Alternative 1 does not include the operations related to the 2008 USFWS BO RPA Component 3 (Action 4), Fall X2 requirement while the No Action Alternative includes it. Therefore, the average September through December X2 position under Alternative 1 would be eastward by over 6 km compared to the No

Action Alternative during the wetter years. In the drier years September through December average X2 position is similar under both scenarios.

Overall, Alternative 1 likely would have adverse effects on Delta Smelt, as compared to the No Action Alternative, primarily due to the potential for increased percentage entrainment during larval and juvenile life stages, and less favorable location of Fall X2 in wetter years, and on average. Given the current condition of the Delta Smelt population, even small differences between alternatives may be important.

Longfin Smelt

The effects of the Alternative 1 as compared to the No Action Alternative were analyzed based on the direction and magnitude of OMR flows during the period (December through June) when adult, larvae, and young juvenile Longfin Smelt are present in the Delta in the vicinity of the export facilities (Appendix 5A). The analysis was augmented with calculated Longfin Smelt abundance index values (Appendix 9G) per Kimmerer et al. (2009), which is based on the assumptions that lower X2 values reflect higher flows and that transporting Longfin Smelt farther downstream leads to greater Longfin Smelt survival. The index value indicates the relative abundance of Longfin Smelt and not the calculated population.

The OMR flows would generally be negative in all months under Alternative 1, with the long-term average ranging from -3,700 to -7,400 cfs from December through June (Appendix 5A). The OMR flows generally would be more negative during this time period under Alternative 1 as compared to the No Action Alternative. The greatest differences between alternatives would be in April and May, where long-term average OMR flows would be negative under Alternative 1 and positive under the No Action Alternative (Appendix 5A, Table C-17-4). The increase in the magnitude of negative flows, with negative flows in April and May, under Alternative 1 as compared to the No Action Alternative could increase the potential for entrainment of Longfin Smelt at the export facilities.

Under Alternative 1, Longfin Smelt abundance index values range from 947 under critical water year conditions to a high of 15,822 under wet water year conditions, with a long-term average value of 7,257. Under the No Action Alternative, Longfin Smelt abundance index values range from 1,147 under critical water year conditions to a high of 16,635 under wet water year conditions, with a long-term average value of 7,951.

Results indicate that the Longfin Smelt abundance index values would be lower in every water year type under Alternative 1 than they would be under the No Action Alternative, with a long-term average index for Alternative 1 that is almost 10 percent lower than the long-term average index for the No Action Alternative. For below normal, dry, and critical water years, the Longfin Smelt abundance index values would be over 20 percent lower under Alternative 1 than they would be under the No Action Alternative, with the greatest difference (26.2 percent) predicted under dry conditions. Based on the Longfin Smelt abundance indices, Alternative 1 likely would have adverse effects on Longfin Smelt, as compared to the No Action Alternative.

Overall, based on the increase in frequency and magnitude of negative OMR flows and the lower Longfin Smelt abundance index values, especially in dry and critical years, potential adverse effects on the Longfin Smelt population under Alternative 1 likely would be greater than under the No Action Alternative.

Sacramento Splittail

Under Alternative 1, flows entering the Yolo Bypass generally would be higher than under the No Action Alternative from December through March, especially during wetter years (Appendix 5A, Table C-26-1). These increases would occur during periods of relatively high flow in the bypass, and could slightly increase the area of inundation. Thus, Alternative 1 could result in a slight increase in spawning habitat for Sacramento Splittail as a result of the increased area of potential habitat (inundation). Given the relatively minor changes in flows into the Yolo Bypass, and the inherent uncertainty associated with the resolution of the CalSim II model (average monthly outputs), it is concluded that there would be no definitive difference in effects on Sacramento Splittail between Alternative 1 and the No Action Alternative.

Reservoir Fishes

The analysis of effects associated with changes in operation on reservoir fishes relied on evaluation of changes in available habitat (reservoir storage) and anticipated changes in black bass nesting success.

Changes in Available Habitat (Storage)

Changes in CVP and SWP water supplies and operations under Alternative 1 as compared to the No Action Alternative generally would result in higher reservoir storage in CVP and SWP reservoirs in the Central Valley Region. Storage levels in Shasta Lake, Lake Oroville, and Folsom Lake would be higher under Alternative 1 as compared to the No Action Alternative, as summarized in Tables 5.12 through 5.14, in the fall and winter months due to the inclusion of Fall X2 criteria under the No Action Alternative.

The highest increases in Shasta Lake and Lake Oroville storage could be in excess of 20 percent. Storage in Folsom Lake and New Melones could be increased by up to around 10 percent in some months of some water year types. Additional information related to monthly reservoir elevations is provided in Appendix 5A, CalSim II and DSM2 Modeling. It is anticipated that aquatic habitat within the CVP and SWP water supply reservoirs is not limiting; however, storage volume is an indicator of how much habitat is available to fish species inhabiting these reservoirs. Therefore, the amount of habitat for reservoir fishes could increase under Alternative 1 as compared to the No Action Alternative.

Changes in Black Bass Nesting Success

As shown in Appendix 9F, black bass nest survival in CVP and SWP reservoirs is anticipated to be near 100 percent in March and April due to increasing reservoir elevations. For May and June, the likelihood of nest survival for Largemouth

Bass in Shasta Lake being in the 40 to 100 percent range is similar under Alternative 1 and the No Action Alternative; however, nest survival of greater than 40 percent is likely only in about 20 percent of the years evaluated. The likelihood of high nest survival for Smallmouth Bass in Shasta Lake exhibits nearly the same pattern. For Spotted Bass, the likelihood of nest survival being greater than 40 percent is high (nearly 100 percent) from March to May under both Alternative 1 and the No Action Alternative. For June, Spotted Bass nest survival would be less than for May due to greater daily reductions in water surface elevation as Shasta Lake is drawn down. The likelihood of nest survival being greater than 40 percent is about 10 percent less under Alternative 1 as compared to the No Action Alternative.

For May and June, the likelihood of nest survival for Largemouth Bass in Lake Oroville being in the 40 to 100 percent range is somewhat (4 to 10 percent) lower under Alternative 1 than under the No Action Alternative. However, in June, nest survival of greater than 40 percent is likely only in about 35 percent of the years evaluated under Alternative 1. The likelihood of high nest survival for Smallmouth Bass in Lake Oroville exhibits nearly the same pattern. For Spotted Bass, the likelihood of nest survival being greater than 40 percent is high (over 90 percent) in May under both Alternative 1 and the No Action Alternative with the likelihood of greater than 40 percent survival being similar under Alternative 1 and the No Action Alternative. For June, Spotted Bass nest survival would be less than for May due to greater daily reductions in water surface elevation as Lake Oroville is drawn down. The likelihood of survival being greater than 40 percent is substantially lower (nearly 20 percent) under Alternative 1 as compared to the No Action Alternative.

Black bass nest survival in Folsom Lake is near 100 percent in March, April, and May due to increasing reservoir elevations. For June, the likelihood of nest survival for Largemouth Bass and Smallmouth Bass in Folsom Lake being in the 40 to 100 percent range is about 5 percent lower under Alternative 1 than the No Action Alternative. For Spotted Bass, nest survival for June would be less than for May due to greater daily reductions in water surface elevation. However, the likelihood of survival being greater than 40 percent is around 5 percent lower under Alternative 1 as compared to the No Action Alternative.

Summary of Effects on Reservoir Fishes

The analysis of the effects of Alternative 1 and the No Action Alternative for reservoir fish relied on CalSim II output for reservoir storage levels and water surface elevation changes as described in Appendix 9F. As described above, reservoir storage is anticipated to be increased under Alternative 1 relative to the No Action Alternative and this increase could affect the amount of warm and cold water habitat available within the reservoirs. However, it is unlikely that aquatic habitat within the CVP and SWP water supply reservoirs is limiting.

The analysis of black bass nest survival based on changes in water surface elevation during the spawning period indicated that the likelihood of high (>40 percent) nest survival in most of the reservoirs would be similar in March, April, and May under Alternative 1 and the No Action Alternative, but somewhat lower in June. Most black bass spawning likely occurs prior to June, such that drawdowns during June would likely affect only a small proportion of the spawning population. Thus, it is concluded that effects on black bass nesting success would be similar under Alternative 1 and the No Action Alternative.

Pacific Lamprey

Little information is available on factors that influence populations of Pacific Lamprey in the Sacramento River, but they are likely affected by many of the same factors as salmon and steelhead because of the parallels in their life cycles.

Changes in Water Temperature

The following describes anticipated changes in average monthly water temperature in the Sacramento, Feather, and American rivers and the potential for those changes to affect Pacific Lamprey.

Sacramento River

Long-term average monthly water temperature in the Sacramento River at Keswick Dam under Alternative 1 would generally be similar (less than 0.5°F difference) to water temperatures under the No Action Alternative. An exception is during September and October of critical dry years when water temperatures could be up to 1.1°F and 0.8°F lower, respectively, under Alternative 1 as compared to the No Action Alternative and up to 1°F warmer in September of wetter years (Appendix 6B, Table 5-5-1). A similar temperature pattern generally would be exhibited downstream at Ball's Ferry, Jelly's Ferry, and Bend Bridge, with average monthly temperatures increasing in a downstream direction and temperature differences between scenarios progressively decreasing except in September (up to 2.8°F warmer) at Bend Bridge) during wetter years under Alternative 1. Due to the similarity of water temperatures under Alternative 1 and the No Action Alternative from January through the summer, there would be little difference in potential effects on Pacific Lamprey adults during their migration, holding, and spawning periods.

Feather River

Long-term average monthly water temperature in the Feather River in the low flow channel generally were predicted to be similar (less than 0.5°F differences) under Alternative 1 and the No Action Alternative, except during November and December when average monthly water temperatures would be up to 1.4°F lower in some water year types (Appendix 6B, Table B-20-1). Average monthly water temperatures in September under Alternative 1 generally could be up to 1.3°F higher than under the No Action Alternative in wetter years. Although temperatures in the river would become progressively higher in the downstream directions, the differences in water temperatures between Alternative 1 and the No Action Alternative would exhibit a similar pattern at the downstream locations (Robinson Riffle and Gridley Bridge), with water temperature differences between Alternative 1 and the No Action Alternative generally decreasing in most water year types However, water temperatures from July to September under Alternative 1 could be somewhat (0.7°F to 1.6°F) warmer on average and up to 4.0°F warmer at the confluence with Sacramento River in wetter years

Due to the similarity of water temperatures under Alternative 1 and the No Action Alternative from January through the summer, there would be little difference in potential effects on Pacific Lamprey adults during their migration, holding, and spawning periods under Alternative 1 and the No Action Alternative.

American River

Average monthly water temperatures in the American River at Nimbus Dam under Alternative 1 generally would be similar (differences less than 0.5°F) to the No Action Alternative, with the exception of during June and August, when water temperatures under Alternative 1 could be as much as 0.9°F lower in below normal years. This pattern generally would persist downstream to Watt Avenue and the mouth, although temperatures under Alternative 1 would be up to 1.6°F and 2.0°F lower, respectively, than under the No Action Alternative in June. In addition, average monthly water temperatures at the mouth generally would be higher under Alternative 1 than the No Action Alternative in September of wetter years when water temperatures under Alternative 1 could be up to 1.7°F warmer. Due to the similarity of water temperatures under Alternative 1 and the No Action Alternative from January through the summer, there would be little difference in potential effects on Pacific Lamprey adults during their migration, holding, and spawning periods.

Summary of Effects on Pacific Lamprey

In general, Pacific Lamprey can tolerate higher temperatures than salmonids, up to around 72°F during their entire life history. Based on the similar water temperatures during their spawning and incubation period under Alternative 1, it is likely that conditions for and effects on Pacific Lamprey in the Sacramento, Feather, and American rivers would be similar under Alternative 1 and the No Action Alternative. This conclusion likely applies to other species of lamprey that inhabit these rivers (e.g., River Lamprey).

Striped Bass, American Shad, and Hardhead

Changes in operations influence temperature and flow conditions that could affect Striped Bass, American Shad, and Hardhead. The following describes those changes and their potential effects.

Changes in Water Temperature

Changes in water temperature that affect Striped Bass, American Shad, and Hardhead could occur in the Sacramento, Feather, and American rivers. The following describes temperature conditions in those water bodies.

Sacramento River

Long-term average monthly water temperatures in the Sacramento River at Keswick Dam under Alternative 1 would generally be similar (less than 0.5°F difference) to water temperatures under the No Action Alternative An exception is during September and October of critical dry years when water temperatures could be up to 1.1°F and 0.8°F lower, respectively, under Alternative 1 as compared to the No Action Alternative and up to 1°F warmer in September of wetter years (Appendix 6B, Table 5-5-1). A similar water temperature pattern generally would be exhibited downstream at Ball's Ferry, Jelly's Ferry, and Bend Bridge, with average monthly water temperatures increasing in a downstream direction and temperature differences between scenarios progressively increasing (up to 0.9°F cooler) in June and up to 4.6°F warmer in September during the wetter years under Alternative 1 relative to the No Action Alternative. In general, Striped Bass, American Shad, and Hardhead can tolerate higher temperatures than salmonids. Therefore, it is unlikely that the slightly reduced temperatures during some months would have adverse effects on these species.

Feather River

Average monthly water temperature in the Feather River in the low flow channel generally were predicted to be similar (less than 0.5°F differences) under Alternative 1 and the No Action Alternative, except during November and December when average monthly water temperatures would be up to 1.4°F lower in some water year types (Appendix 6B, Table B-20-1). Average monthly water temperatures in September under Alternative 1 could be up to 1.3°F warmer than under the No Action Alternative in the wetter years. Although temperatures in the river would become progressively lower in the downstream directions, the differences between Alternative 1 and No Action Alternative would exhibit a similar pattern at the downstream locations (Appendix 6B, Table B-23-1). As described above for the Sacramento River, Striped Bass, American Shad, and Hardhead can tolerate higher temperatures than salmonids. Therefore, it is unlikely that the slightly reduced temperatures during some months would have adverse effects on these species in the Feather River.

American River

Average monthly water temperatures in the American River at Nimbus Dam under Alternative 1 generally would be similar (differences less than 0.5°F) to the No Action Alternative, with the exception of during June and August, when differences under Alternative 1 could be as much as 0.9°F lower in below normal years. This pattern generally would persist downstream to Watt Avenue and the mouth, although temperatures under Alternative 1 would be up to 1.6°F and 2.0°F lower, respectively, than under the No Action Alternative in June. As described above for the Sacramento River, Striped Bass, American Shad, and Hardhead can tolerate higher temperatures than salmonids. Therefore, it is unlikely that the slightly reduced temperatures during some months would have adverse effects on these species in the American River.

Changes in Position of X2

Alternative 1 would result in a more eastward X2 position as compared to the No Action Alternative during April and May, with similar values in June (Appendix 5A, Section C Table C-16-1). Based on Kimmerer (2002) and Kimmerer et al. (2009), this change in X2 would likely reduce the survival index and the habitat index as measured by salinity for Striped Bass and abundance and habitat index for American Shad.

Summary of Effects on Striped Bass, American Shad, and Hardhead

In general, Striped Bass, American Shad, and Hardhead can tolerate higher temperatures than salmonids. Based on the similar water temperatures during their spawning and incubation period under Alternative 1, it is likely that thermal conditions for and effects on Striped Bass, American Shad, and Hardhead in the Sacramento, Feather, and American rivers would be similar under Alternative 1 and the No Action Alternative. Overall, however, Alternative 1 likely would have slightly greater potential for adverse effects on Striped Bass and American Shad as compared to the No Action Alternative, primarily due to the potential for reduced survival during larval and juvenile life stages, and less favorable location of Spring X2 on average.

Stanislaus River/Lower San Joaquin River

Fall-Run Chinook Salmon

Changes in operations influence temperature and flow conditions that could affect fall-run Chinook Salmon in the Stanislaus River downstream of Goodwin Dam and in the San Joaquin River below Vernalis. The following describes those changes and their potential effects.

Changes in Water Temperature (Stanislaus River)

Average monthly water temperatures in the Stanislaus River at Goodwin Dam under Alternative 1 and the No Action Alternative generally would be similar (differences less than 0.5°F), with small differences in critical dry years when Alternative 1 would 0.8°F and 1.3°F cooler on average than under the No Action Alternative during June and September, respectively, and 0.7°F warmer in November (Appendix 6B, Table B-1-1).

Downstream at Orange Blossom Bridge, average monthly water temperatures in October under Alternative 1 would be higher in all water year types than under the No Action Alternative by as much as 1.9°F. In most other months, water temperatures under Alternative 1 and the No Action Alternative generally would be similar. An exception to this pattern occurs in April when average monthly water temperatures in all water year types would be higher under Alternative 1 by as much as about 1.2°F (Appendix 6B, Table B-18-1).

This water temperature pattern would continue downstream to the confluence with the San Joaquin River, although temperatures would progressively increase, as would the magnitude of difference between Alternative 1 and No Action Alternative. Increases in average monthly water temperatures in October and April would be more pronounced under Alternative 1, with average differences as much as 2.7°F in October and 2.0 F in April (Appendix 6B, Table B-19-1) relative to the No Action Alternative. The magnitude of differences in average monthly water temperatures between Alternative 1 and the No Action Alternative in May and June also would increase relative to the upstream locations with average June water temperatures being 2.4°F cooler under Alternative 1 in wet years.

Based on the life history timing for fall-run Chinook Salmon, the higher water temperatures in October under Alternative 1 may increase the likelihood of adverse effects on fall-run Chinook Salmon spawning and egg incubation as compared to the No action Alternative.

Changes in Exceedance of Water Temperature Thresholds Appendix

While specific water temperature thresholds for fall-run Chinook Salmon in the Stanislaus River are not established, temperatures generally considered suitable for fall-run Chinook Salmon spawning (56°F) would be exceeded in October and November about 30 and 25 percent of the time, respectively at Goodwin Dam under Alternative 1 (Appendix 6B, Figures B-17-1 and B-17-2). Similar exceedances would occur under the No Action Alternative, although slightly more frequently in November. Water temperatures for rearing generally would be below 56°F, except in May when average monthly water temperatures would reach about 60°F under both Alternative 1 and the No action Alternative (Appendix 6B, Figure B-17-8).

Downstream at Orange Blossom Bridge, water temperatures suitable for fall-run Chinook Salmon spawning (56°F) would be exceeded frequently under both Alternative 1 and the No Action Alternative during October and November. Under Alternative 1, average monthly water temperatures would exceed 56°F about 85 percent of the time in October. This, would be about 28 percent more frequently than under the No Action Alternative. In November, average monthly water temperatures would exceed 56°F about 28 percent of the time under Alternative 1, which would be about 5 percent less frequent than under the No Action Alternative (Appendix 6B, Figure B-18-2).

From January through May, rearing fall-run Chinook Salmon would be subjected to average monthly water temperatures that exceed 56° in March (less than 10 percent of the time) and May (about 20 percent of the time) under Alternative 1, which is about 10 percent less frequently than under the No Action Alternative in May (Appendix 6B, Figure B-18-8).

Changes in Egg Mortality (Stanislaus River)

For fall-run Chinook Salmon in the Stanislaus River, the long-term average egg mortality rate is predicted to be around 7 percent, with higher mortality rates (in excess of 15 percent) occurring in critical dry years under Alternative 1. Overall, egg mortality in the Stanislaus River would be similar under Alternative 1 and the No Action Alternative (Appendix 9C, Table B-1).

Changes in Delta Hydrodynamics

San Joaquin River-origin fall-run Chinook Salmon smolts are most abundant in the Delta during the months of April, May and June. Near the confluence of the San Joaquin River and the Mokelumne River, the median proportion of positive velocities was slightly lower under Alternative 1 relative to the No Action Alternative in April and May and similar in June (Appendix 9K). In Old River downstream of the facilities, the median proportion of positive velocities was substantially lower in April and May under Alternative 1 relative to No Action

Alternative but became more similar in June. In Old River upstream of the facilities, the median proportion of positive velocities was slightly to moderately lower for Alternative 1 relative to No Action Alternative in April and May, respectively and moderately lower in June. On the San Joaquin River downstream of the Head of Old River, the median proportion of positive velocities was slightly to moderately higher under Alternative 1 relative to No Action Alternative in April and May, respectively, whereas values were similar in June.

Changes in Junction Entrainment

Median entrainment probabilities at the Head of Old River were much lower under Alternative 1 relative to the No Action Alternative during April and May. The median entrainment probability was similar under both alternatives in the month of June (Appendix 9L). At the Turner Cut junction, median entrainment probabilities under Alternative 1 were slightly higher than under the No Action Alternative in June. During April and May, entrainment probabilities were more divergent with moderately higher values for Alternative 1 relative to No Action Alternative. Overall, entrainment was slightly lower at the Columbia Cut junction relative to Turner Cut but patterns of entrainment between these two alternatives were similar. Patterns at the Middle River and Old River junctions were similar to those observed at Columbia and Turner Cut junctions.

Summary of Effects on Fall-Run Chinook Salmon

In the Stanislaus River, the analysis of the effects of Alternative 1 and the No Action Alternative for fall-run Chinook Salmon relied on the water temperature model output for the rivers at various locations downstream of Goodwin Dam. The temperature model outputs for each of the fall-run Chinook Salmon life stages suggest that thermal conditions and effects on fall-run Chinook Salmon in the Stanislaus River generally would be similar under both scenarios, although water temperatures could be somewhat less suitable for fall-run Chinook Salmon spawning/egg incubation under Alternative 1. This conclusion is supported by the water temperature threshold exceedance analysis that indicated that suitable water temperatures for fall-run Chinook Salmon spawning and egg incubation would be exceeded slightly less frequently in November, but substantially more frequently in October under Alternative 1. Suitable water temperatures for fall-run Chinook Salmon rearing would be exceeded somewhat less frequently under Alternative 1. Results of the analysis using Reclamation’s salmon mortality model indicate that there would be little difference in fall-run Chinook Salmon egg mortality under Alternative 1 and the No Action Alternative.

Implementation of a fish passage project under the No Action Alternative, although intended to address the limited availability of suitable habitat for steelhead in the Stanislaus River reaches downstream of Goodwin Dam, could provide some benefit to fall-run Chinook Salmon if passage for adult fall-run Chinook Salmon was provided and additional habitat could be accessed. Any potential benefit to fall-run Chinook Salmon under the No Action Alternative relative to Alternative 1 is uncertain. The potential benefits of actions under the No Action Alternative intended to increase the efficiency of the Tracy and

Skinner Fish Collection Facilities could improve the overall salvage survival of fall-run Chinook Salmon relative to Alternative 1.

The results of the numerical models suggest that Alternative 1 is less likely to result in adverse effects on fall-run Chinook Salmon than the No Action Alternative. However, discerning a meaningful difference between these two scenarios based on the quantitative results is not possible because of the similarity in results (generally differences less than 5 percent) and the inherent uncertainty of the models. In addition, adverse effects of the No Action Alternative could be balanced by the potentially beneficial effects resulting from the RPA actions evaluated qualitatively for the No Action Alternative. Overall, given the small differences in the numerical model results and the inherent uncertainty in the temperature model, as well as the potential for benefits associated with the RPA actions under the No Action Alternative, it is concluded that there would be no definitive difference in effects on fall-run Chinook Salmon between Alternative 1 and the No Action Alternative.

Steelhead

Changes in operations that influence temperature and flow conditions in the Stanislaus River downstream of Goodwin Dam and the San Joaquin River below Vernalis could affect steelhead. The following describes those changes and their potential effects.

Changes in Water Temperature (Stanislaus River)

Average monthly water temperatures in the Stanislaus River at Goodwin Dam under Alternative 1 and the No Action Alternative generally would be similar (differences less than 0.5°F), with small differences in critical dry years when water temperatures under Alternative 1 would 0.8°F and 1.3°F cooler on average than under the No Action Alternative during June and September, respectively, and 0.7°F warmer in November (Appendix 6B, Table B-17-1).

Downstream at Orange Blossom Bridge, average monthly water temperatures in October under Alternative 1 would be higher in all water year types than the No Action Alternative by as much as 1.9°F. In most other months, water temperatures under Alternative 1 and the No Action Alternative generally would be similar (less than 0.5°F differences), except in April when average monthly water temperatures in all water year types would be higher under Alternative 1 by as much as about 1.2°F in the drier years (Appendix 6B, Table B-18-1).

This water temperature pattern would continue downstream to the confluence with the San Joaquin River, although temperatures would progressively increase, as would the magnitude of difference between Alternative 1 and the No Action Alternative. Increases in average monthly water temperatures in October and April would be more pronounced under Alternative 1, with average differences as much as 2.7°F (Appendix 6B, Table B-19-1) relative to the No Action Alternative. The magnitude of differences in average monthly water temperatures between Alternative 1 and the No Action Alternative in May and June also would increase relative to the upstream locations with average June water temperatures being 2.4°F cooler under Alternative 1 in wet years.

Overall, the water temperature differences between Alternative 1 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on steelhead in the Stanislaus River. Based on the life history timing for steelhead, the slightly lower temperatures in June and September of drier years under Alternative 1 may decrease the likelihood of adverse effects to steelhead rearing in the Stanislaus River; the higher temperatures in October under Alternative 1 may increase the likelihood of adverse effects on adult steelhead during their upstream migration.

Changes in Exceedance of Water Temperature Thresholds (Stanislaus River)

Average monthly water temperatures in the Stanislaus River at Orange Blossom Bridge would frequently exceed the temperature threshold (56°F) established for adult steelhead migration under both Alternative 1 and No Action Alternative during October and November. Under Alternative 1, average monthly water temperatures would exceed 56°F about 85 percent of the time in October which is about 28 percent more frequently than under the No Action Alternative (Appendix 6B, Figure B-18-1). In November, average monthly water temperatures would exceed 56°F about 28 percent of the time under Alternative 1, which would be about 5 percent less frequent than under the No Action Alternative (Appendix 6B, Figure B-18-2).

From January through May, the temperature threshold at Orange Blossom Bridge is 55°F, which is intended to support steelhead spawning. This threshold would not be exceeded under either Alternative 1 or No Action Alternative during January or February. From March through May, however, exceedances would occur under both Alternative 1 and the No Action Alternative in each month, with the threshold most frequently exceeded (43 percent) under Alternative 1 in May (Appendix 9N). Water temperatures under Alternative 1 would exceed the threshold 5 percent less frequently in March, 6 percent less frequently in May, and 17 percent more frequently in April than under the No Action Alternative.

From June through November, the temperature threshold of 65°F established to support steelhead rearing would be exceeded by both Alternative 1 and No Action Alternative in all months but November, and would exceed the threshold by 16 percent of the time in July under both Alternative 1 and the No Action Alternative. The differences between Alternative 1 and the No Action Alternative range from 1 percent less frequent exceedance in October to 4 percent more frequent exceedance in June under the No Action Alternative.

Average monthly water temperatures also would exceed the threshold (52°F) established for smoltification at Knights Ferry. At Goodwin Dam, about 4 miles upstream of Knights Ferry, average monthly water temperatures under Alternative 1 would exceed 52°F in March, April, and May about 9 percent, 31 percent, and 66 percent of the time, respectively. Water temperatures under

Alternative 1 would result in exceedances occurring about 1 to 2 percent more frequently during the January through May period. Farther downstream at Orange Blossom Bridge, the temperature threshold for smoltification is higher (57°F) and would be exceeded less frequently. The magnitude of the exceedance also would be less. Average monthly water temperatures under Alternative 1 and the No Action Alternative would not exceed the threshold during January through March. In April and May, exceedances of 8 percent and 10 percent would occur under Alternative 1, which represent a frequency of about 6 percent more than the No Action Alternative in April and about an 8 percent lower frequency in May.

Overall, the differences in exceedance frequency between Alternative 1 and the No Action Alternative would be relatively small, with the exception of substantial differences in the frequency of exceedances in October when the average monthly water temperatures under Alternative 1 would exceed the threshold for adult steelhead migration about 28 percent more frequently and in April during the spawning period when the exceedance frequency would be about 17 percent more. Given the frequency of exceedance under both Alternative 1 and No Action Alternative and the generally stressful temperature conditions in the river, the substantial differences in October and April under Alternative 1 suggest that there would be more potential to result in adverse effects on steelhead under Alternative 1 than under the No Action Alternative. Even during months when the differences would be relatively small, the slightly higher frequency of exceedances under Alternative 1 suggest that there would be more potential to result in adverse effects on steelhead under Alternative 1 than under the No Action Alternative.

Changes in Delta Hydrodynamics

San Joaquin River-origin steelhead generally move through the Delta during spring; however, there is less information on their timing relative to Chinook Salmon. Thus, hydrodynamics in the entire January through June period have the potential to affect juvenile steelhead. For a description of potential hydrodynamic effects on steelhead, see the descriptions for winter-run Chinook Salmon in the Sacramento Basin and fall-run Chinook Salmon in the San Joaquin River basin above.

Summary of Effects on Steelhead

The analysis of the effects of Alternative 1 and the No Action Alternative for steelhead relied on the water temperature model output for the rivers at various locations downstream of Goodwin Dam. The temperature model outputs for each of the steelhead life stages suggest that thermal conditions and effects on steelhead in all of these streams generally would be similar under both scenarios, although water temperatures could be somewhat less suitable for steelhead rearing under Alternative 1. Water temperatures could be somewhat more suitable during the adult upstream migration period under Alternative 1 than the No Action Alternative. This conclusion is supported by the water temperature threshold exceedance analysis that indicated that the water temperature threshold for steelhead migration would be exceeded substantially more frequently on October, but somewhat more frequently in November under Alternative 1. The water temperature threshold for steelhead spawning would also be exceeded substantially more frequently in May, but somewhat less frequently in other months under Alternative 1. The water temperature threshold for steelhead rearing generally would be exceeded less frequently under Alternative 1 while the temperature thresholds for smoltification would be exceeded more frequently in most months.

The differences in the magnitude and frequency of exceedance of suitable temperatures for the various lifestages under Alternative 1 could affect the potential for adverse effects on the steelhead populations in the Stanislaus River. However, the direction and magnitude of this effect is uncertain. Implementation of the fish passage program under the No Action Alternative intended to address the limited availability of suitable habitat for steelhead in the Stanislaus River reaches downstream of Goodwin Dam could provide a benefit to Central Valley steelhead in the Stanislaus River. This is particularly important in light of anticipated increases in water temperature associated with climate change in 2030. Thus, it is concluded that the potential for adverse effects on steelhead under Alternative 1 would be greater, principally because Alternative 1 does not include fish passage to address water temperatures critical to steelhead sustainability over the long term with climate change by 2030.

White Sturgeon

Evidence of White Sturgeon spawning has been recorded in the San Joaquin River upstream of the confluence with the Stanislaus River. While flows in the San Joaquin River upstream of the Stanislaus River are expected be similar under all alternatives, flow contributions from the Stanislaus River could influence water temperatures in the San Joaquin River where White Sturgeon eggs or larvae may occur during the spring and early summer. The magnitude of influence on water temperature would depend on the proportional flow contribution of the Stanislaus River and the temperatures in both the Stanislaus and San Joaquin rivers. The potential for an effect on White Sturgeon eggs and larvae would be influenced by the proportion of the population occurring in the San Joaquin River. In consideration of this uncertainty, it is not possible to distinguish potential effects on White Sturgeon between alternatives.

Reservoir Fishes

The analysis of effects associated with changes in operation on reservoir fishes relied on evaluation of changes in available habitat (reservoir storage) and anticipated changes in black bass nesting success.

Changes in CVP and SWP water supplies and operations under Alternative 1 as compared to the No Action Alternative would result in higher storage levels in New Melones Reservoir under Alternative 1 as compared to the No Action Alternative, as summarized in Table 5.16, due to lower instream releases to support fish flows under Alternative 1.

Storage in New Melones could be increased by up to around 10 percent in some months of some water year types under Alternative 1 compared to the No Action Alternative. Additional information related to monthly reservoir elevations is provided in Appendix 5A, CalSim II and DSM2 Modeling. Assuming that storage volume is an indicator of how much habitat is available to fish species inhabiting the reservoir, the amount of habitat for reservoir fishes could be increased under Alternative 1 as compared to the No Action Alternative.

As shown in Appendix 9F, Largemouth Bass and Smallmouth Bass nest survival is anticipated to always be above 40 percent under both Alternative 1 and the No Action Alternative in March. For April, the likelihood that nest survival of Largemouth Bass and Smallmouth Bass is between 40 and 100 percent is reasonably high (nearly 80 percent), although about 13 percent higher under Alternative 1 as compared to the No Action Alternative. For May, nest survival is anticipated to be similar under Alternative 1 and the No Action Alternative. For June, the likelihood of survival being greater than 40 percent for Largemouth Bass and Smallmouth Bass in New Melones Reservoir is about 8 percent lower under Alternative 1 as compared to the No Action Alternative. For Spotted Bass, nest survival from March through June is anticipated to be near 100 percent in every year under both Alternative 1 and No Action Alternative. Most black bass spawning likely occurs prior to June, such that drawdowns during June would likely affect only a small proportion of the spawning population. Thus, it is concluded that effects on black bass nesting success would be similar under Alternative 1 and the No Action Alternative.

Other species

Changes in operations that influence temperature and flow conditions in the Stanislaus River downstream of Keswick Dam and the San Joaquin River at Vernalis could affect other species such as lampreys, Hardhead, and Striped Bass.

As described above, average monthly water temperatures in the Stanislaus River at Goodwin Dam under Alternative 1 and No Action Alternative generally would be similar. Downstream at Orange Blossom Bridge, average monthly water temperatures in the November to March period under Alternative 1 generally would be similar to, although somewhat lower than, under the No Action Alternative. In April and October, average monthly water temperatures in all water year types would be higher under Alternative 1 and in September, water temperatures would be lower under Alternative 1 compared to the No Action Alternative. This temperature pattern would continue downstream to the confluence with the San Joaquin River, although temperatures would progressively increase, as would the magnitude of difference between Alternative 1 and No Action Alternative (Appendix 6B, Table B-19-1).

In general, lamprey species can tolerate higher temperatures than salmonids, up to around 72°F during their entire life history. Because lamprey ammocoetes remain in the river for several years, any substantial flow reductions or temperature increases could result in adverse effects on larval lamprey. Given the similar flows and temperatures during their spawning and incubation period, it is likely that the potential to affect lamprey species in the Stanislaus and San Joaquin rivers would be similar under Alternative 1 and the No Action Alternative.

In general, Striped Bass and Hardhead also can tolerate higher temperatures than salmonids. Given the similar temperatures during their spawning and incubation period, it is likely that the potential to affect Striped Bass and Hardhead in the Stanislaus and San Joaquin rivers would be similar under Alternative 1 and the No Action Alternative.

San Francisco Bay Area Region

Killer Whale

Southern Resident killer whales (Southern Residents) are thought to rely heavily upon salmon as their main source of prey (about 96 percent of their diet) throughout the areas and times for which reliable data on prey consumption are available (Ford and Ellis 2006). Studies have indicated that Chinook Salmon generally constitute a large percentage of the Southern Resident salmon diet, with some indications that Chinook Salmon are strongly preferred at certain times in comparison to other salmonids (Ford and Ellis 2006; Hanson et al. 2007). Results have also suggested that Chinook Salmon from ESUs from California to British Columbia are being consumed by Southern Residents (Hanson et al. 2007).

Best available data on the abundance and composition of Central Valley Chinook Salmon indicates that approximately 75 percent of all Central Valley-origin Chinook Salmon available for consumption by Southern Residents are produced by Central Valley fall-run Chinook Salmon hatcheries (Palmer-Zwhalen and Kormos 2012; Table 9). Most Central Valley hatchery fall-run Chinook Salmon production is released directly into San Francisco Bay, and thus bypass potential impacts from water project operations. Even where there might be a nexus with water project operations, the purpose of Central Valley fall-run Chinook Salmon hatchery programs is to produce large numbers of fish independent of freshwater conditions. Since fall-run Chinook Salmon hatcheries came on-line more than forty years ago, the only period of exceptionally low returns was principally attributed to unusual ocean conditions (Lindley et al. 2007).

Ocean commercial and recreational fisheries annually harvest hundreds of thousands of Chinook salmon. The Northwest Region of NMFS (NMFS 2009c) used a model that estimates prey reduction associated with the salmon fishery and which considers the metabolic requirements of Southern Residents and the remaining levels of prey availability. Their analysis concluded that the salmon fishery was not likely to result in jeopardy for Southern Residents. Given conclusions from NMFS (2009c), and the fact that at least 75 percent of fall-run Chinook Salmon available for Southern Residents are produced by Central Valley hatcheries, it is likely that Central Valley fall-run Chinook Salmon as a prey base for killer whales would not be appreciably affected by any of the alternatives.

9.4.3.2.2 Alternative 1 Compared to the Second Basis of Comparison

As described in Chapter 3, Description of Alternatives, Alternative 1 is identical to the Second Basis of Comparison.

9.4.3.3 Alternative 2

The CVP and SWP operations under Alternative 2 are identical to the CVP and SWP operations under the No Action Alternative, as described in Chapter 3, Description of Alternatives. Alternative 2 would not include implementation of fish passage actions under the 2009 NMFS BO. As described in Chapter 4, Approach to Environmental Analysis, Alternative 2 is compared to the No Action Alternative and the Second Basis of Comparison.

9.4.3.3.1 Alternative 2 Compared to the No Action Alternative

Trinity River Region

The CVP and SWP operations under Alternative 2 are identical to the CVP and SWP operations under the No Action Alternative. Therefore, fish and aquatic resources conditions at Trinity Lake and along the Trinity River and lower Klamath River under Alternative 2 would be the same as under the No Action Alternative.

Central Valley Region

The CVP and SWP operations under Alternative 2 are identical to the CVP and SWP operations under the No Action Alternative. Therefore, physical conditions that affect aquatic resources under Alternative 2 would be the same as under the No Action Alternative. However, salmonid survival could be less under Alternative 2 due to the lack of fish passage actions to move fish to portions of the Sacramento, American, and Stanislaus rivers that would provide cooler temperatures for spawning and rearing under the No Action Alternative. In addition, Alternative 2 would not include various actions that would occur under the No Action Alternative intended to benefit salmonids and sturgeon, such as structural improvements for temperature control on the American River; gravel augmentation, floodplain restoration and inundation flows, and freshwater migratory habitat restoration in the Stanislaus River; and measures to increase the efficiency of the Tracy and Skinner Fish Collection Facilities. Thus, it is concluded that the potential for adverse effects on salmonids and sturgeon under Alternative 2 would be greater than under the No Action Alternative.

San Francisco Bay Area Region

Killer Whale

It is unlikely that the Chinook Salmon prey base of killer whales, supported heavily by hatchery production of fall-run Chinook Salmon, would be appreciably affected by any of the alternatives.

9.4.3.3.2 Alternative 2 Compared to the Second Basis of Comparison

Trinity River Region

The CVP and SWP operations under Alternative 2 are identical to the CVP and SWP operations under the No Action Alternative. Therefore, changes in aquatic resources at Trinity Lake and along the Trinity River and lower Klamath River under Alternative 2 as compared to the Second Basis of Comparison would be the same as the impacts described in Section 10.4.4.1, No Action Alternative Compared to the Second Basis of Comparison.

Central Valley Region

The CVP and SWP operations under Alternative 2 are identical to the CVP and SWP operations under the No Action Alternative. Therefore, changes in physical conditions that affect aquatic resources in the Central Valley Region under Alternative 2 as compared to the Second Basis of Comparison would be the same as the impacts described for the No Action Alternative Compared to the Second Basis of Comparison. Actions to provide fish passage to portions of the Sacramento, American, and Stanislaus rivers upstream of their dams would not be undertaken under Alternative 2 or the Second Basis of Comparison.

San Francisco Bay Area Region

Killer Whale

As described above for the comparison of Alternative 1 to the No Action Alternative, it is unlikely that the Chinook Salmon prey base of killer whales, supported heavily by hatchery production of fall-run Chinook Salmon, would be appreciably affected by any of the alternatives.

9.4.3.4 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 with modified OMR flow criteria and New Melones Reservoir operations. Alternative 3 also includes the following items that are not included in the No Action Alternative or the Second Basis of Comparison and would affect fish and aquatic resources.

- Implement predator control programs for black bass, Striped Bass, and Sacramento Pikeminnow to protect salmonids and Delta Smelt as follows:
    - Black bass catch limit changed to allow catch of 12-inch fish with a bag limit of 10
    - Striped Bass catch limit changed to allow catch of 12-inch fish with a bag limit of 5
    - Establish a Sacramento Pikeminnow sport-fishing reward program with a 8-inch limit at $2/fish
- Establish a trap and haul program for juvenile salmonids entering the Delta from the San Joaquin River in March through June as follows:
    - Begin operation of downstream migrant fish traps upstream of the Head of Old River on the San Joaquin River
    - “Barge” all captured juvenile salmonids through the Delta, release at Chipps Island.
    - Tag subset of fish in order to quantify effectiveness of the program
    - Attempt to capture 10 percent to 20 percent of out-migrating juvenile salmonids

- Work with Pacific Fisheries Management Council, CDFW, and NMFS to minimize harvest mortality of natural origin Central Valley Chinook Salmon, including fall-run Chinook Salmon, by evaluating and modifying ocean harvest for consistency with Viable Salmonid Population Standards; including harvest management plan to show that abundance, productivity, and diversity (age-composition) are not appreciably reduced.

As described in Chapter 4, Approach to Environmental Analysis, Alternative 3 is compared to the No Action Alternative and the Second Basis of Comparison.

9.4.3.4.1 Alternative 3 Compared to the No Action Alternative

Trinity River Region

Coho Salmon

The analysis of effects associated with changes in operation on Coho Salmon was conducted using temperature model outputs for Lewiston Dam to anticipate the likely effects on conditions in the Trinity River downstream of Lewiston Dam for Coho Salmon.

Long-term average monthly water temperatures in the Trinity River at Lewiston Dam under Alternative 3 generally would be similar to the temperatures that would occur under the No Action Alternative (Appendix 6B, Table B-1-2). An exception occurs during November when long-term average water temperatures are increased by 3.3°F under Alternative 3 relative to the No Action Alternative in critical years. In addition, water temperatures under Alternative 3 could be as much as 1.5°F cooler than under the No Action Alternative in December of below normal years. Overall, the temperature differences between Alternative 3 and the No Action Alternative would be relatively minor and likely would have little effect on Coho Salmon in the Trinity River. The higher water temperatures in November of critical years and lower temperatures in December of below normal years under Alternative 3 would likely have little effect on Coho Salmon as water temperatures in the Trinity River are typically low during this time period.

The USFWS established a water temperature threshold of 56°F for Coho Salmon spawning in the reach of the Trinity River from Lewiston to the confluence with the North Fork Trinity River from October through December. Although not entirely reflective of water temperatures throughout the reach, the temperature model provides average monthly water temperature outputs for Lewiston Dam, which may provide perspective on temperature conditions in the reach below. Under Alternative 3, the spawning temperature threshold would be exceeded about 6 percent of the time in October, about 2 percent less frequently than under the No Action Alternative. In November, average water temperatures under Alternative 3 would not exceed the threshold, whereas average monthly water temperatures the No Action Alternative would exceed the threshold about 2 percent of the time. The threshold would not be exceeded in December under either scenario (Appendix 9N).

Overall, the temperature model outputs for each of the Coho Salmon life stages suggest that the temperature of water released at Lewiston Dam generally would be similar under both scenarios, although the exceedance of water temperature thresholds would be less frequent under Alternative 3. Given the similarity of the results and the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), it is concluded that Alternative 3 and the No Action Alternative are likely to have similar effects on the Coho Salmon population in the Trinity River.

Spring-run Chinook Salmon

The analysis of effects associated with changes in operation on spring-run Chinook Salmon was conducted using temperature model outputs for Lewiston Dam to anticipate the likely effects on conditions in the Trinity River downstream of Lewiston Dam.

As described above for Coho Salmon, the differences in long-term average monthly water temperatures between Alternative 3 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on spring-run Chinook Salmon in the Trinity River. The substantially higher (3.3°F) water temperatures in November of critical dry years and lower (by 1.5°F) in December of below normal years under Alternative 3 would likely have little effect on spring-run Chinook Salmon as water temperatures in the Trinity River are typically low during this time period.

In July, water temperatures in the Trinity River at Lewiston Dam would not exceed the 60°F threshold for spring-run Chinook Salmon holding under Alternative 3, although this threshold would be exceeded 1 percent of the time under the No Action Alternative. Under both Alternative 3 and the No Action Alternative, average monthly water temperatures in the Trinity River at Lewiston Dam would exceed 60°F two percent of the time in August. In September, the threshold for spawning (56°F) would be exceeded under both scenarios about 9 percent of the time. Overall, the differences in the frequency of threshold exceedance between Alternative 3 and the No Action Alternative would be relatively minor. However, temperature conditions under Alternative 3 could be slightly less likely to affect spring-run Chinook Salmon holding than under the No Action Alternative because of the reduced frequency of exceedance of the 60°F threshold at Lewiston Dam in July.

The majority of spring-run Chinook Salmon in the Trinity River are produced in the South Fork Trinity watershed. Although the water temperature and flow changes could have slight beneficial effects on spring-run Chinook Salmon in the Trinity River, these effects would not occur in every year and are not anticipated to be substantial based on the relatively small differences in flows and water temperatures under Alternative 3 as compared to the No Action Alternative.

Overall, Alternative 3 is likely to have similar effects on the spring-run Chinook Salmon population in the Trinity River as compared to the No Action Alternative. However, the implementation of the Hatchery Management Plan (RPA Action II.6.3) under the No Action Alternative could reduce the impacts of hatchery Chinook Salmon on natural spring-run Chinook Salmon in the Trinity River, and increase the genetic diversity and diversity of run-timing for these stocks relative to Alternative 3.

Fall-Run Chinook Salmon

The analysis of effects associated with changes in operation on fall-run Chinook Salmon was conducted using temperature model outputs for Lewiston Dam to anticipate the likely effects on conditions in the Trinity River downstream of Lewiston Dam. The Reclamation Salmon Survival Model also was applied to assess changes in egg mortality.

As described above for Coho Salmon, the temperature differences between Alternative 3 and No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on fall-run Chinook Salmon in the Trinity River. The higher water temperatures (as much as 3.3°F) in November of critical years (and lower temperatures in December) under Alternative 3 would likely have little effect on fall-run Chinook Salmon as water temperatures in the Trinity River are typically low during this time period.

The temperature threshold and months during which it applies for fall-run Chinook Salmon are the same as those for Coho Salmon. Under Alternative 3, the 56°F threshold for fall-run Chinook Salmon spawning would be exceeded about 6 percent of the time in October, about 2 percent less frequently than under the No Action Alternative. In November and December, average water temperatures under Alternative 3 would not exceed the threshold, whereas average monthly water temperatures the No Action Alternative would exceed the threshold about 2 percent of the time in November, with no exceedances in December. Overall, the differences in the frequency of threshold exceedance between Alternative 3 and the No Action Alternative would be relatively minor. Temperature conditions under the Alternative 3 could be slightly less likely to affect fall-run Chinook Salmon spawning than under the No Action Alternative because of the slightly reduced frequency of exceedance of the 56°F threshold at Lewiston Dam in October. However, this would occur prior to the peak spawning period (November-December) for fall-run Chinook Salmon.

The temperatures described above for the Trinity River downstream of Lewiston Dam are reflected in the analysis of egg mortality using the Reclamation model (Appendix 9C). For fall-run Chinook Salmon in the Trinity River, the long-term average egg mortality rate is predicted to be relatively low (around 4 percent), with higher mortality rates (over 10 percent) occurring in critical dry years under Alternative 3 (Appendix 9C, Table B-5). Overall, egg mortality under Alternative 3 and the No Action Alternative would be similar in all water year types.

Although the water temperature and flow changes suggest a lower potential for adverse effects on fall-run Chinook Salmon in the Trinity River, these effects would not occur in every year and are not anticipated to be substantial based on the relatively small differences in flows and water temperatures (and similar egg mortality) under Alternative 3 as compared to the No Action Alternative.

Overall, Alternative 3 is likely to have similar effects on fall-run Chinook Salmon in the Trinity River as compared to the No Action Alternative. However, the implementation of the Hatchery Management Plan (RPA Action II.6.3) under the No Action Alternative could reduce the impacts of hatchery Chinook Salmon on natural fall-run Chinook Salmon in the Trinity River, and increase the genetic diversity and diversity of run-timing for these stocks relative to Alternative 3.

Steelhead

The analysis of effects associated with changes in operation on steelhead was conducted using temperature model outputs for Lewiston Dam to anticipate the likely effects on conditions in the Trinity River downstream of Lewiston Dam.

As described above for Coho Salmon, the temperature differences between Alternative 3 and No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on steelhead in the Trinity River. In critical dry years, increased water temperatures in November under Alternative 3 could increase the likelihood of adverse effects on migrating adult steelhead, although water temperatures are relatively low at this time of year.

The temperature threshold and months during which it applies for steelhead are the same as those for Coho Salmon. Overall, the differences in the frequency of threshold exceedance between Alternative 3 and the No Action Alternative would be relatively minor and are unlikely to affect steelhead spawning in the Trinity River. While average monthly temperatures would be similar overall, the slight reduction in the frequency of threshold exceedance provided by Alternative 3 during warm periods in October and November suggest that temperature conditions under Alternative 3 could be slightly less likely to affect steelhead than under the No Action Alternative.

Although water temperatures under Alternative 3 suggest a slightly lower potential for adverse effects on steelhead in the Trinity River, the relatively small differences in flows and water temperatures under Alternative 3 as compared to the No Action Alternative would likely have similar effects on steelhead in the Trinity River as compared to the No Action Alternative.

Green Sturgeon

Changes in operations that influence temperature and flow conditions in the Trinity River downstream of Lewiston Dam could influence Green Sturgeon. The following describes those changes and their potential effects.

As described in the Affected Environment, Green Sturgeon spawn in the lower reaches of the Trinity River during April through June, and water temperatures above about 63°F are believed stressful to embryos (Van Eenennaam et al. 2005). Average monthly water temperature conditions during April through June in the Trinity River at Lewiston Dam under Alternative 3 are similar and do not exceed 58°F during this period. Water temperatures in the downstream reaches where Green Sturgeon spawn would be higher, although temperature conditions likely would be controlled by other factors (e.g., ambient air temperatures and tributary inflows) rather than water operations at Trinity and Lewiston dams. Therefore, given the similarities between average monthly water temperatures at Lewiston Dam under Alternative 3 and the No Action Alternative, it is likely that temperature conditions for Green Sturgeon in the Trinity River and lower Klamath River and estuary would be similar under both scenarios.

Reservoir Fishes

The analysis of effects associated with changes in operation on reservoir fishes relied on evaluation of changes in available habitat (reservoir storage) and anticipated changes in black bass nesting success.

Changes in CVP water supplies and operations under Alternative 3 as compared to the No Action Alternative would result in higher reservoir storage in Trinity Lake. Storage in Trinity Lake could be increased up to around 10 percent in some months of some water year types. Additional information related to monthly reservoir elevations is provided in Appendix 5A, CalSim II and DSM2 Modeling.

Aquatic habitat in Trinity Lake may not be limiting; however, storage volume is an indicator of how much habitat is available to fish species inhabiting these reservoirs. Therefore, the amount of habitat for reservoir fishes could be increased somewhat under Alternative 3 as compared to the No Action Alternative.

Results of the bass nesting success analysis are presented in Appendix 9F, Reservoir Fish Analysis Documentation. Bass nest survival in Trinity Lake is predicted to be near 100 percent in March and April due to increasing reservoir elevations. For May, the likelihood of survival for Largemouth and Smallmouth Bass in Trinity Lake being in the 40 to 100 percent range would be similar under Alternative 3 and the No Action Alternative. For June, the likelihood of survival being greater than 40 percent for Largemouth and Smallmouth Bass would be somewhat lower than in May and would be similar under Alternative 3 and the No Action Alternative. For Spotted Bass, the likelihood of survival being greater than 40 percent would be 100 percent in May under both Alternative 3 and the No Action Alternative. For June, Spotted Bass survival in Trinity Lake would be less than for May due to greater daily reductions in water surface elevation. The likelihood of survival being greater than 40 percent would be similar (near 100 percent) under Alternative 3 and the No Action Alternative.

Overall, the comparison of storage and the analysis of nesting suggest that effects of Alternative 3 on reservoir fishes would be similar to those under the No Action Alternative.

Pacific Lamprey

Little information is available on factors that influence populations of Pacific Lamprey in the Trinity River, but they are likely affected by many of the same factors as salmon and steelhead because of the parallels in their life cycles. On average, the temperature of water released at Lewiston Dam under Alternative 3 would be similar to (within 0.5°F) (Appendix 6B). The highest increases in flow would be less than 10 percent in the Trinity River, with a smaller relative increase in the lower Klamath River and Klamath River estuary (Appendix 5A).

Overall, it is likely that effects on Pacific Lamprey would be similar under both Alternative 3 and the No Action Alternative. This conclusion likely also applies to other species of lamprey that inhabit the Trinity and lower Klamath rivers (e.g., River Lamprey).

Eulachon

It is uncertain whether Eulachon has been extirpated from the Klamath River. Given that the highest increases in flow would be less than 10 percent in the Trinity River (Appendix 5A), with a smaller relative increase in the lower Klamath River and Klamath River estuary, and that water temperatures in the Klamath River (Appendix 6B) would be unlikely to be affected by changes upstream at Lewiston Dam, it is likely that Alternative 3 would have a similar potential to influence Eulachon in the Klamath River as the No Action Alternative.

Sacramento River System

Winter-run Chinook Salmon

Changes in operations that influence temperature and flow conditions in the Sacramento River downstream of Keswick Dam could affect winter-run Chinook Salmon. The following describes those changes and their potential effects.

Changes in Water Temperature

Average monthly water temperature in the Sacramento River at Keswick Dam under Alternative 3 generally would be similar to (less than 0.5°F difference) water temperatures under the No Action Alternative during most months of the year (Appendix 6B, Table B-5-2). In September, average water temperatures in wetter years could be increased by up to 0.8°F and decreased by up to 1.2°F in critical years. A similar temperature pattern generally would be exhibited downstream at Ball’s Ferry, Jelly’s Ferry, and Bend Bridge, with average monthly temperatures progressively increasing in the downstream direction (e.g., average difference of about 2°F between Keswick Dam and Bend Bridge) (Appendix 6B, Table B-8-2). The water temperature differences between Alternative 3 and the No Action Alternative in September of wetter years would increase to as high as 2.6°F warmer under Alternative 3, while the differences in drier years could reach 1.0°F cooler in September of drier years.

Overall, the temperature differences between Alternative 3 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on winter-run Chinook Salmon in the Sacramento River. The increased water temperatures in September of wetter years under Alternative 3 could increase the likelihood of adverse effects on winter-run Chinook Salmon egg incubation and fry rearing during this water year type. The slightly lower water temperatures in September of drier years under Alternative 3 could reduce the likelihood of adverse effects on winter-run Chinook Salmon fry rearing in or outmigrating from the Sacramento River. There would be little difference in potential effects on spawning of winter-run Chinook Salmon due to the similar water temperatures during the April to June time period under Alternative 3 as compared to the No Action Alternative.

Changes in Exceedances of Water Temperature Thresholds

With the exception of April, average monthly water temperatures under both Alternative 3 and the No Action Alternative would show exceedances of the water temperature threshold of 56°F established in the Sacramento River at Ball's Ferry for winter-run Chinook Salmon spawning and egg incubation in every month, with exceedances under both as high as about 49 percent and 42 percent, respectively, in some months. Under Alternative 3, the temperature threshold generally would be exceeded less frequently than it would under the No Action Alternative (by about 2 percent to 4 percent) in June through August, with the temperature threshold in September exceeded about 6 percent more frequently under Alternative 3 than the No Action Alternative. Farther downstream at Bend Bridge, the frequency of exceedances would increase, with exceedances under both Alternative 3 and the No Action Alternative as high as nearly 90 percent in some months. Under Alternative 3, temperature exceedances generally would be less frequent (by up to 8 percent) than under the No Action Alternative, with the exception of September, when exceedances under Alternative 3 would be about 26 percent more frequent.

Overall, there would be substantial differences in the frequency of threshold exceedance between Alternative 3 and the No Action Alternative, particularly in September. While temperature conditions under Alternative 3 could be less likely to affect winter-run Chinook Salmon egg incubation than under the No Action Alternative because of the reduced frequency of exceedance of the 56°F threshold from April through August, the substantial increase in the frequency of exceedance in September under Alternative 3 may increase the likelihood of adverse effects on winter-run Chinook Salmon egg incubation during this limited portion of the spawning and egg incubation period.

Changes in Egg Mortality

The temperatures described above for the Sacramento River downstream of Keswick Dam are reflected in the analysis of egg mortality using Reclamation's salmon mortality model (Appendix 9C). For winter-run Chinook Salmon in the Sacramento River, the long-term average egg mortality rate is predicted to be relatively low (around 5 percent), with higher mortality rates (exceeding 25 percent) occurring in critical dry years under Alternative 3. In critical dry years the average egg mortality rate would be 6 percent less than under the No Action Alternative (Appendix 9C, Table B-4). Overall, winter-run Chinook Salmon egg mortality in the Sacramento River under Alternative 3 and the No Action Alternative would be similar, except in critical dry water years.

Changes in Weighted Usable Area

As an indicator of the amount of suitable spawning habitat for winter-run Chinook Salmon between Keswick Dam and Battle Creek, modeling results indicate that, in general, there would be similar amounts of spawning habitat available from April through August under Alternative 3 as compared to the No Action

Alternative (Appendix 9E, Weighted Usable Area Analysis). Modeling results also indicate that, in general, there would be similar amounts of suitable fry rearing habitat available from June through October under Alternative 3. Similar to the results for fry rearing WUA, modeling results indicate that there would be similar amounts of suitable juvenile rearing habitat available during the juvenile rearing period from July to May under Alternative 3 and the No Action Alternative.

Changes in SALMOD Output

SALMOD results indicate that potential juvenile production would be similar under Alternative 3 as compared to the No Action Alternative (Appendix 9D, Table B-4-6).

Changes in Delta Passage Model Output

The Delta Passage Model predicted similar estimates of annual Delta survival across the 81-year time period for winter-run Chinook Salmon between Alternative 3 and the No Action Alternative (Appendix 9J). Median Delta survival would be 0.354 for Alternative 3 and 0.349 for the No Action Alternative.

Changes in Delta Hydrodynamics

Winter-run Chinook Salmon smolts are most abundant in the Delta during January, February, and March. On the Sacramento River near the confluence of Georgiana Slough, the median proportion of positive velocities under Alternative 3 was indistinguishable from the No Action Alternative (Appendix 9K). On the San Joaquin River near the Mokelumne River confluence, the median proportion of positive velocities would be indistinguishable between these two alternatives. In Old River downstream of the facilities, the median proportion of positive velocities would be similar under Alternative 3 and the No Action Alternative in January, February, and March. In Old River upstream of the facilities, the median proportion of positive velocities also would be similar under Alternative 3 and the No Action Alternative in these months. On the San Joaquin River downstream of Head of Old River, the percent of positive velocities would be similar under both alternatives in January, February and March.

Changes in Junction Entrainment

For all junctions examined, entrainment probabilities for both scenarios would be similar under Alternative 3 and the No Action Alternative from January through March (Appendix 9L).

Changes in Salvage

Salvage of Sacramento River-origin Chinook Salmon is predicted to be similar under Alternative 3 relative to No Action Alternative during the three months when winter-run Chinook Salmon are most abundant in the Delta (January, February, March; (Appendix 9M).

Changes in Oncorhynchus Bayesian Analysis Output

Escapement of winter-run Chinook Salmon and Delta survival was modeled by the Oncorhynchus Bayesian Analysis (OBAN) model for winter-run Chinook salmon. Escapement was generally lower under Alternative 3 as compared to the No Action Alternative (Appendix 9I). The median abundance under Alternative 3 was higher in only 5 of the 22 years of simulation (1971 to 2002), and there was typically greater than a 25 percent chance that Alternative 3 values would be lower than under the No Action Alternative. Median delta survival was consistently lower (by approximately 7 percent) under Alternative 3 as compared to the No Action Alternative. However, the probability intervals indicated that no difference between scenarios was a likely outcome. Thus delta survival was not responsible for the temporal patterns in relative escapement. Since the ocean conditions were equivalent across, scenarios, the differences under Alternative 3 were likely due to differences in survival in the life stages upstream of the delta (i.e., due to differences in temperature and flow at Bend Bridge).

Changes in Interactive Object-Oriented Simulation Output

The IOS model predicted similar adult escapement trajectories for winter-run Chinook Salmon between Alternative 3 and the No Action Alternative across the 81 years (Appendix 9H). Under Alternative 3 median adult escapement was 4,025 and under the No Action Alternative, median escapement was 3,935.

Similar to adult escapement, the IOS model predicted similar egg survival time trajectories for winter-run Chinook Salmon between Alternative 3 and No Action Alternative across the 81 water years. Under Alternative 3 median egg survival was 0.987 and under the No Action Alternative median egg survival was 0.990.

Changes in Predator Management

The fish predator assemblage of the Delta is dominated by invasive predators, with the exception of the Sacramento Pikeminnow (Brown and Michniuk 2007; Nobriga and Feyrer 2007, National Research Council 2010; Cavallo et al. 2012, NRC 2012, Brown 2013). With the exception of Striped Bass, there is little population-level information for fish predators including Largemouth Bass and Sacramento Pikeminnow and there is even less information for Smallmouth Bass and White and Channel Catfish (Grossman et al. 2013). It is important to note that, in addition to predation by native and non-native fishes, there has been extensive modification of the hydrology, loss of tidal freshwater wetlands, increases in non-native submerged aquatic vegetation such as *Egeria densa*, and other effects of human population growth within the Delta, which also undoubtedly influence the survival of salmonids in the Delta (Brown and Michniuk 2007; National Research Council 2010, 2012).

Bowen et al. (2009 and 2010) describe salmonid behavior in the vicinity of the Head of Old River Barrier and predation from the release point upstream at Durham Ferry. Predation in this short reach seemed to be increased during the lower flows in 2009 and during later release in 2010. While this two year study observed a variable and negative relationship between flow and survival past a Head of Old River Barrier, there remains uncertainty in this due to the actual barrier structures implemented and how they affected predator habitat in this reach.

Although it is well documented that Striped Bass can feed heavily on juvenile salmon and steelhead in the rivers, as they migrate seaward, many of the salmon eaten are likely to be hatchery-reared fish; juveniles from natural spawning may be more wary and encounter lower predation rates. It is thought that predation on hatchery-reared juveniles may buffer wild fish from such predation (Moyle and Bennett 2010). Much of the predation on juvenile salmon seems to take in place in conjunction with artificial structures and release practices. These include releases of fish from hatcheries and those trucked to the estuary from the export facilities in the south Delta (DWR 2010).

In general, Striped Bass are opportunistic predators that tend to forage on whatever prey are most abundant, from benthic invertebrates to their own young to juvenile salmon and American Shad (Stevens 1966, Moyle 2002, Nobriga and Feyrer 2008). Striped Bass are unlikely to be a major predator of Delta Smelt because Delta Smelt are semi-transparent (making them hard to see in turbid water) and do not school, unlike more favored prey such as Threadfin Shad, juvenile Striped Bass, and Mississippi Silverside. Delta Smelt were a minor item in Striped Bass diets when they were highly abundant in the early 1960s (Stevens 1966), as well as in recent years at record low abundance (Nobriga and Feyrer 2008).

Predator control measures are included in Alternative 3, including an increased bag limit (10/day) with a minimum size limit of 12 inches on Striped Bass and black bass. In addition, a sport reward program for Sacramento Pikeminnow ($2/fish > 8 inches) would be implemented to encourage fishing for and removal of this native predatory fish.

A number of studies have been conducted on predation effects in the Delta, and a recent (2013) workshop was held to assess the status of information and potentially establish conclusions regarding the importance of fish predation on salmonid populations in the Delta (Grossman et al. 2013). The workshop concluded that:

> “Available data and analyses have generated valuable information regarding aspects of the predation process in the Delta but do not provide unambiguous and comprehensive estimates of fish predation rates on juvenile salmon or steelhead nor on population-level effects for these species in the Delta.”

And:

> “Juvenile salmon are clearly consumed by fish predators and several studies indicate that the population of predators is large enough to effectively consume all juvenile salmon production. However, given extensive flow modification, altered habitat conditions, native and non-native fish and avian predators, temperature and dissolved oxygen limitations, and overall reduction in historical salmon population size, it is

> not clear what proportion of juvenile mortality can be directly attributed to fish predation. Fish predation may serve as the proximate mechanism of mortality in a large proportion of the population but the ultimate causes of mortality and declines in productivity are less clear."

The proposed bag and size limits are intended and expected to encourage more fishing effort for and greater harvest of Striped Bass and black bass species, resulting in a reduction in the Striped Bass and black bass populations throughout the Delta. It is reasonable to assume that removing or relaxing restrictions on the harvest of these predatory species would lead to a substantial reduction in their number. However, whether or not this reduction would lead to a substantial benefit or population-level effect on salmonid populations is unknown (Moyle and Bennett 2010). For the proposed (under Alternative 3) predator reduction program to be effective, it must be true that predation by Striped Bass and black bass regulates populations of salmon, steelhead, and smelt, with predation by other species (other fish, birds, marine mammals, etc.) playing a minor role. The program may not be effective, or the effectiveness would be reduced if other predators exhibit compensatory increases in predation if Striped Bass and black bass are removed.

As noted above, the modification of the hydrology, loss of tidal freshwater wetlands, increases in non-native submerged aquatic vegetation, and other effects of human population growth within the Delta play a role in the survival of salmonids in the Delta and contribute to the uncertainty that any predator reduction program will have the desired results. It is unknown whether reducing Striped bass and black bass populations can measurably compensate for the large changes to the estuary and watershed, which also contribute to reduced populations of salmon, steelhead and smelt.

In addition to the proposed bag and size limits, Alternative 3 includes a proposal to implement a sport reward program for Sacramento Pikeminnow to encourage fishing for and removal of predatory Sacramento Pikeminnow. It is unknown whether a Sacramento Pikeminnow bounty would be feasible under California regulations. Currently, the Sacramento Pikeminnow is regulated under CCR Title 14, section 5.95 (no limit or season), sections 2.25 and 2.30 (bow and arrow and spear fishing) and section 1.87 (no wastage of fish). Therefore, any fishing practice, derby or bounty program in which the Sacramento Pikeminnow is wasted would be in violation of the regulations. In addition, Sacramento Pikeminnow is listed as a "game fish" in commission regulations (CCR Title 14, section 230) and a permit is required before any prizes can be offered to take them.

Regardless of whether a Sacramento Pikeminnow reward system is feasible to implement, the effectiveness of such a program is not assured. This same approach to predator reduction is ongoing in the Columbia River through the Northern Pikeminnow (*Ptychocheilus oregonensis*) Sport-Reward Program sponsored by Bonneville Power Administration that began in 1991. The program seeks to maintain 10 to 20 percent exploitation rate on Northern Pikeminnow throughout the Columbia River by paying anglers $4 to $8 to harvest fish >

228 mm (>9 inches) in total length. In 2012, a total of 158,159 fish were harvested in the sport-reward fishery. Vouchers for 156,837 untagged fish were submitted for payment totaling rewards of $1,016,672. System-wide pikeminnow exploitation efforts suggest that the desired 10 to 20 percent exploitation rate has been achieved for a number of years (Porter 2012). The program has removed over 2.2 million fish from 1998-2009 and is believed to have reduced predation on juvenile salmonids; however, predation estimates have varied widely and positive effects on salmonid populations have been difficult to detect (Carey et al. 2012).

Control of undesired and invasive fishes is a common fishery management strategy (Kolar et al. 2010). However, changes in predator abundance produced via removal, augmentation, or invasion can produce unintended consequences (Polis and Strong 1996). It is possible that other species on which Striped Bass prey, such as Mississippi Silverside, would increase in abundance, causing harm by competing with and preying on desired species, particularly Delta Smelt. Mississippi Silversides are important in the diets of 1 to 3 year old Striped Bass; predation by Striped Bass could be regulating the silverside population. Reducing Striped Bass predation pressure on Mississippi Silversides may increase their numbers, which could have negative effects on Delta Smelt through predation on eggs and larvae (Bennett and Moyle 2006).

The predator reduction program under Alternative 3 is intended to improve the survival of listed species (e.g., salmonids and Delta Smelt) by reducing predation on these species. As described above, the program may be difficult to implement, may not be effective, and may cause unintended harm to other native Delta fish species. Consequently, the outcome of the predator management program is highly uncertain. Compared to the No Action Alternative, which does not include a predator reduction program, Alternative 3 may or may not provide a benefit to salmonids and may result in an adverse effect on Delta smelt.

Changes in Ocean Salmon Harvest

Alternative 3 includes an action to change ocean salmon harvest for the purpose of increasing escapement of adult winter-run Chinook Salmon as well as other runs. The following outlines the benefits and challenges associated with such a program.

Central Valley origin Chinook Salmon of all races are harvested in commercial and recreational fisheries off the coast of California. Central Valley origin fall-run Chinook Salmon are the primary target of this harvest. Harvested Chinook Salmon between Point Conception and Bodega Bay were found to be composed of 89-95 percent Central Valley fall-run Chinook Salmon (Winans et al. 2001). More recent studies have shown most Central Valley fall-run Chinook Salmon are produced by hatcheries, and are not of natural origin. Barnett-Johnson et al. (2007) analyzed otolith microstructure from harvested Chinook Salmon and estimated 90 percent were of hatchery origin. Palmer-Zwhalen and Kormos (2012; Table 9) reported data indicating spawning-escapement for Central Valley fall-run Chinook Salmon was composed of 75 percent hatchery origin fish.

Despite the relatively high abundance of hatchery-produced fall-run Chinook Salmon, ocean fisheries are often constrained to protect ESA-listed Chinook Salmon stocks (including Sacramento winter-run and spring-run Chinook Salmon, and Coastal Chinook Salmon), which constitute less than 10 percent of available Chinook Salmon (Winans et al. 2001). This "mixed-stock" fishery is managed by using stock-specific differences in ocean distribution, age at maturity, size-at-date, and/or timing of river entry to help minimize harvest of sensitive stocks. However, such management strategies are only partially effective.

For example, spring-run Chinook Salmon return to freshwater in the spring and thus avoid most ocean harvest during the year in which they mature. However, spring-run Chinook Salmon that mature at age 4 (or older) are subjected to a full season of harvest at "impact levels" comparable to those directed at Central Valley fall-run Chinook Salmon. Harvest managers define "impact rate" as the proportion of a particular stock that will suffer mortality associated with the ocean fishery. Fall-run Chinook Salmon often experience impact rates between 40 and 70 percent.

Thus, the impact of ocean harvest varies substantially by stock, but all stocks are impacted by harvest directed at the most abundant Chinook Salmon population (typically hatchery origin fall-run Chinook Salmon). Several analyses are available that provide a basis for assessing how harvest management identified in Alternative 3 would affect Central Valley Chinook Salmon populations. Though there are political and societal considerations for changes in ocean harvest management, there are no technical or scientific constraints. We have the tools, the knowledge and the ability to manage Chinook ocean harvest in whatever way is needed. As such, Alternative 3 is, from a technical and scientific level, entirely feasible.

Alternative 3 calls for ocean harvest to be managed with the standard of causing no appreciable reduction in viability criteria for natural origin Chinook Salmon. This alternative is addressed separately for Central Valley spring-run, winter-run, and fall-run Chinook Salmon.

Spring-Run Chinook Salmon.

Fifteen years have elapsed since NMFS last updated its spring-run Chinook Salmon ocean harvest Biological Opinion (NMFS 2000). The 2000 BO did not report an estimated "impact rate" for the ocean harvest impact on spring-run Chinook Salmon. The BO reached a non-jeopardy opinion for the impacts of ocean harvest primarily by referring to the growth in Central Valley spring-run Chinook Salmon population which was occurring at that time. Though NMFS (2010) did not provide a quantitative analysis of spring-run Chinook Salmon harvest, Grover et al. (2004) estimated that two thirds of spring-run Chinook Salmon matured at age 4, indicating that a large fraction of the spring-run Chinook Salmon population is annually subject to high impact rates (40 to 70 percent), which would greatly influence population productivity and abundance. Harvest of age-3 spring-run Chinook Salmon is likely to be comparable to that experienced by winter-run Chinook Salmon (which also mature and return to fresh water, missing most of the ocean fishing season).

Though a comparable analysis for spring-run Chinook Salmon is not available, Winship et al. (2013) applied a simulation model that showed a 25 percent impact rate (much less than that likely experienced by age 4 spring-run Chinook Salmon) on winter-run Chinook Salmon substantially decreased population abundance and population resiliency relative to alternatives with less harvest.

Harvest pressure of this intensity can also alter diversity in age at-maturity, a critical factor for population viability (NMFS 2010). The ocean fishery is thought to select against fish that mature later because fish that would do so are vulnerable to harvest for more years (Ricker 1981; Hankin and Healey 1986; Sierra and Lackey 2015), and age at maturity has moderate heritability (Hankin et al. 1993). As such, reduced ocean harvest would contribute substantially to age at-maturity diversity (certainly demographically, if not genetically) and thereby enhance population viability. A downward shift in size and age at maturity also affect fitness by reducing fecundity and reproductive rates (Calduch-Verdiell et al. 2014). Larger females generally have larger and more numerous eggs (Wertheimer et al. 2004), both of which provide reproductive advantages. Larger eggs produce larger juveniles, which tend to have higher survival rates (Quinn 2005) and are more resistance to temperature extremes. Since size and age-at-maturity are heritable, selection for earlier adult maturity leads to a feedback loop in which younger and smaller adults produce offspring that mature earlier at smaller sizes. Change in body size may also influence spawning habitat use where larger fish occupy areas with coarser substrate that smaller fish may not be able to use. Thus, advantages of diversity in age at-maturity could be especially important in degraded and thermally stressful habitats typical of Central Valley tributaries.

Winter-Run Chinook Salmon

NMFS updated their winter-run Chinook Salmon ocean harvest BO in 2010 (NMFS 2010) and concluded:

> *The effect of harvest and indirect mortality associated with the salmon ocean fishery reduces the reproductive capability of this population, and subsequently the entire ESU, by 10-25 percent per brood, when ocean fisheries occur at a level similar to what has been observed for most of the last decade south of Point Arena, California.*
>
> *There is concern about the relatively high impact rate for age-4 fish and the consequences of this relative to the genetic diversity of winter-run. If age at maturity is strongly related to a genetic component, the removal of older fish at a high rate before they can return to spawn, however few of these individuals in the population there might be, could theoretically reduce the potential for that trait to pass on to successive generation. The change in an average life history trait over time, such as age at maturity, has been suggested as evidence for fisheries induced evolution in some situations (Law 2000; Kuparinen and Merilä 2007; Hard et al. 2008).*

NMFS has since implemented changes in ocean harvest regulations intended to reduce impacts, but the effectiveness of those programs is unclear. Winship et al. (2013) applied a simulation model and showed that all current winter-run Chinook Salmon harvest alternatives substantially decreased population abundance and population extinction risk relative to closing recreational and commercial fisheries south of Point Arena. While closing these fisheries may not be a realistic management alternative, Winship et al. (2013) did not consider intermediate harvest management strategies such as a mark-selective fishery (Pyper et al. 2012) or quota based fishing seasons. Currently, about 90 percent of winter-run Chinook Salmon mature at age-3. As identified in the winter-run Chinook Salmon harvest BO (NMFS 2010), diversity in age at maturity is an important viability criterion likely to be adversely impacted by current harvest management; winter-run Chinook Salmon currently maturing at age-4 are subjected to impact rates comparable to those targeting fall-run Chinook Salmon (40 to 70 percent). Given information presented in the spring-run Chinook Salmon section, it seems likely that in the absence of this harvest, winter-run Chinook Salmon would have a larger fraction of their population maturing at age-4 or possibly older. Age-4 and older winter-run Chinook Salmon would enhance demographic population viability, but also benefit the population by more effectively spawning in coarse substrates, and producing more, larger, and more thermally tolerant eggs.

Fall-Run Chinook Salmon.

As indicated previously, fall-run Chinook Salmon produced by Central Valley hatcheries are the most abundant stock harvested off the coast of California. The current management of Central Valley fall-run Chinook Salmon makes no distinction between natural and hatchery fish, and, as such, harvest of natural origin fall-run Chinook Salmon appears to occur at a much higher rate than population productivity can sustain. The recently convened California HSRG concluded:

> *"Fishery harvests that are sustained at high levels by targeting abundant hatchery-origin fish may over-exploit naturally reproducing salmonids and may also induce selection on maturation schedule and other traits… fishery exploitation rates must be in alignment with the productivity of naturally reproducing salmon stocks for the recommendations in this report to be successful at conserving natural salmonid populations" (p. 19)*

> *"The California HSRG also believes that an aggregate escapement target for [the Central Valley natural stocks] that includes returns to hatcheries lacks biological support. The target could theoretically be met if all fish returned to hatcheries and none returned to natural spawning areas, or if all fish in natural spawning areas were of hatchery origin" (p. 21).*

Quantitative analyses of current ocean harvest impacts to natural origin fall-run Chinook Salmon are not currently available. However, impact rates combined with relatively low abundances of natural origin fall-run Chinook Salmon indicate adverse impacts to population viability are likely severe. Changes in harvest strategies which could more effectively target hatchery origin fall Chinook while better protecting natural origin fish would yield substantial benefits. Pyper et al. (2012) analyzed one alternative, a mark-selective fishery, and found that natural origin spawning escapement would increase from 24 to 48 percent.

Managing ocean salmon harvest as described in Alternative 3 would contribute to the abundance, productivity and diversity viability criteria for natural origin spring-run, winter-run, and fall-run Chinook Salmon.

Summary of Effects on Winter-Run Chinook Salmon

The multiple model and analysis outputs described above characterize the anticipated conditions for winter-run Chinook Salmon and their response to change under Alternative 3 as compared to the No Action Alternative. For the purpose of analyzing effects on winter-run Chinook Salmon and developing conclusions, greater reliance was placed on the outputs from the two life cycle models, IOS and OBAN because they each integrate the available information to produce single estimates of winter-run Chinook Salmon escapement. The output from IOS indicated that winter-run Chinook Salmon escapement would be similar under both scenarios, whereas the OBAN results indicated that escapement under Alternative 3 would be lower than under the No Action Alternative.

These model results suggest that effects on winter-run Chinook Salmon would be similar under both scenarios, with a small likelihood that winter-run Chinook Salmon escapement would be lower under Alternative 3 than under the No Action Alternative. This potential distinction between the two scenarios, however, may be increased due to the benefits of implementation of fish passage under the No Action Alternative. This potential beneficial effect and its magnitude would depend on the success of the fish passage program. In addition, RPA actions intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities could improve the overall salvage survival of winter-run Chinook Salmon.

The ocean harvest restriction component of Alternative 3 could increase winter-run Chinook Salmon numbers by reducing ocean harvest and the predator control measures under Alternative 3 could reduce predation on juvenile winter-run Chinook Salmon and thereby increase survival.

Overall, given the small differences, distinguishing a clear difference between alternatives is difficult. The non-operational components associated with Alternative 3 could benefit winter-run Chinook Salmon relative to the No Action Alternative over the short term if successful; however, these measures would not address the long-term temperature challenges in the river downstream of Shasta Dam that would be addressed under the No Action Alternative if fish passage is successful. Even though the success of fish passage is uncertain, it is concluded that the potential for adverse effects on winter-run Chinook Salmon under Alternative 3 would be greater than those under the No Action Alternative, principally because Alternative 3 does not include a strategy to address water temperatures critical to winter-run Chinook Salmon sustainability over the long term with climate change by 2030.

Spring-run Chinook Salmon

Changes in operations that influence temperature and flow conditions in the Sacramento River downstream of Keswick Dam could affect spring-run Chinook Salmon. The following describes those changes and their potential effects.

Changes in Water Temperature

Changes in water temperature that could affect spring-run Chinook Salmon could occur in the Sacramento River, Clear Creek, and Feather River. The following describes temperature conditions in those water bodies.

Sacramento River

Average monthly water temperature in the Sacramento River at Keswick Dam under Alternative 3 relative to the No Action Alternative generally would be similar to (less than 0.5°F differences) water temperatures under the No Action Alternative during most months of the year (Appendix 6B, Table B-5-2). In September, average water temperatures in wetter years would be increased by up to 0.8°F and decreased by up to 1.2°F in critical years. A similar temperature pattern generally would be exhibited downstream at Ball’s Ferry, Jelly’s Ferry, Bend Bridge, and Red Bluff, with average monthly temperatures progressively increasing in the downstream direction (e.g., average difference of about 3°F between Keswick Dam and Red Bluff). The water temperature differences between Alternative 3 and the No Action Alternative in September of wetter years would increase to as high as 3.0°F warmer under Alternative 3 at Red Bluff, while the differences in water temperatures in September associated with Alternative 3 during drier years would remain similar to the differences at upstream locations.

Overall, the temperature differences between Alternative 3 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on spring-run Chinook Salmon in the Sacramento River. The increased water temperatures in September of wetter years under Alternative 3 could increase the likelihood of adverse effects on spring-run Chinook Salmon spawning and egg incubation during this water year type. The slightly lower water temperatures in September of drier years under Alternative 3 would reduce the likelihood of adverse effects on spring-run Chinook Salmon spawning and egg incubation in the Sacramento River as compared to the No Action Alternative. There would be little difference in potential effects on spring-run Chinook Salmon holding in other summer months due to the similar water temperatures during this time period under Alternative 3 and the No Action Alternative.

Clear Creek

Average monthly water temperatures in Clear Creek at Igo under Alternative 3 would be similar to (less than 0.5°F differences) water temperatures under the No Action Alternative with the exception of May when average monthly temperatures under Alternative 3 would be somewhat higher (up to about 0.8°F) than the No Action Alternative (Appendix 6B, Table B-3-2). The lower water temperatures in May associated with the No Action Alternative reflect the effects of the additional water that would be discharged from Whiskeytown Dam to meet the spring attraction flow requirements to promote attraction of spring-run

Chinook Salmon into the creek. Overall, water temperature conditions for spring-run Chinook Salmon in Clear Creek would be similar under Alternative 3 and the No Action Alternative.

Feather River

Average monthly water temperatures in the Feather River low flow channel under Alternative 3 generally would be similar (within 0.5°F) to water temperatures under the No Action Alternative, except in November and December (differences as much as 1.6°F lower in December in below normal water years) (Appendix 6B, Table B-20-2). In September average monthly water temperatures under Alternative 3 could be somewhat higher (up to about 1.5°F) in wetter years than under the No Action Alternative. Although temperatures in the river would become progressively higher in the downstream direction, the differences between Alternative 3 and the No Action Alternative would exhibit a similar pattern at the downstream locations (Robinson Riffle and Gridley Bridge), with temperatures under Alternative 3 and the No Action Alternative generally becoming more similar at the confluence with the Sacramento River, except in September when the water temperature under Alternative 3 could be up to 4.4 °F higher than under the No Action Alternative and in June when temperatures under Alternative 3 could be up to 0.8°F cooler in drier years (Appendix 6B, Table B-23-2).

Overall, the temperature differences in the Feather River between Alternative 3 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on spring-run Chinook Salmon in the Feather River. The somewhat lower water temperatures in November and December under Alternative 3 would likely have little effect on spring-run Chinook Salmon as water temperatures in the Feather River are typically low during this time period. The somewhat higher water temperatures in September of wetter years may increase the likelihood of adverse effects on spring-run Chinook Salmon egg incubation and fry rearing in the Feather River. There would be little difference in potential for adverse effects on spring-run Chinook Salmon holding over the summer due to the similar water temperatures during this time period under Alternative 3 and the No Action Alternative.

Changes in Exceedances of Water Temperature Thresholds

Changes in water temperature could result in the exceedance of established water temperature thresholds for spring-run Chinook Salmon in the Sacramento River, Clear Creek, and Feather River. The following describes the extent of those exceedance for each of those water bodies.

Sacramento River

Average monthly water temperatures under both Alternative 3 and the No Action Alternative would show exceedances of the water temperature threshold of 56°F established in the Sacramento River at Red Bluff for spring-run Chinook Salmon (spawning and egg incubation) in October, November, and again in April. The exceedances would occur at the greatest frequency in October (78 percent of the time under Alternative 3). The water temperature threshold would be exceeded less frequently in November (8 percent of the time) and not exceeded at all during

December through March under Alternative 3. As water temperatures warm in the spring, the threshold would be exceeded in April by 14 percent under Alternative 3. In the months when the greatest frequency of exceedances occur (October, November, and April), model results generally indicate that the threshold would be exceeded less frequently (by up to 4 percent in October) under Alternative 3 than under the No Action Alternative. Temperature conditions in the Sacramento River under Alternative 3 could be less likely to affect spring-run Chinook Salmon egg incubation than under the No Action Alternative because of the decreased frequency of exceedance of the 56°F threshold in October, November, and April.

Clear Creek

Average monthly water temperatures under both Alternative 3 and the No Action Alternative would not exceed the water temperature threshold of 60°F established in Clear Creek at Igo for spring-run Chinook Salmon pre-spawning and rearing in June through August. However, water temperatures under Alternative 3 would exceed the water temperature threshold of 56°F established for spawning in September and October about 12 percent to 11 percent of the time, respectively. Water temperatures under Alternative 3 could exceed the threshold about 4 percent less frequently than under the No Action Alternative in September and about 2 percent less frequently in October. Temperature conditions in Clear Creek under Alternative 3 could be less likely to affect spring-run Chinook Salmon spawning than under the No Action Alternative because of the decreased frequency of exceedance of the 56°F threshold in September and October. However, this difference may be partially offset if the thermal stress reduction measures associated with 2009 NMFS BO RPA Action I.1.5 under the No Action Alternative are successful in improving water temperatures in Clear Creek.

Feather River

Average monthly water temperatures under both Alternative 3 and the No Action Alternative would exceed the water temperature threshold of 56°F established in the Feather River at Robinson Riffle for spring-run Chinook Salmon egg incubation and rearing) during some months, particularly in October and November, and March and April, when temperature thresholds could be exceeded frequently (Appendix 9N). The frequency of exceedance would be highest (about 97 percent) in October, a month in which average monthly water could get as high as about 68°F under Alternative 3. However, water temperatures under Alternative 3 would exceed the temperature threshold about 1 percent less frequently than the No Action Alternative from October to December, and 1 percent more frequently in March.

The established water temperature threshold of 63°F for rearing during May through August would be exceeded often under both Alternative 3 and the No Action Alternative in May and June, but not at all in July and August. Water temperatures under Alternative 3 would exceed the rearing temperature threshold about 5 percent less frequently than under the No Action Alternative in May, with the same likelihood of exceedance in June. Temperature conditions in the Feather River under Alternative 3 could be less likely to affect spring-run Chinook

Salmon spawning and rearing than under the No Action Alternative because of the decreased frequency of exceedance of the water temperature thresholds.

Changes in Egg Mortality

The temperature differences described above are reflected in the analysis of egg mortality using the Reclamation model (Appendix 9C). For spring-run Chinook Salmon in the Sacramento River, the long-term average egg mortality rate is predicted to be relatively high (exceeding 20 percent), with high mortality rates (around 80 percent) occurring in critical dry years under Action Alternative 3. In critical dry years the average egg mortality rate would be 6.6 percent less under Alternative 3 than under the No Action Alternative (Appendix 9C, Table B-3). Overall, spring-run Chinook Salmon egg mortality in the Sacramento River under Alternative 3 and the No Action Alternative would be similar, except in critical dry water years.

Changes in Weighted Usable Area

Weighted usable area curves are available for spring-run Chinook Salmon in Clear Creek. As described above, flows in Clear Creek downstream of Whiskeytown Dam are not anticipated to differ under Alternative 3 relative to the No Action Alternative except in May due to the release of spring attraction flows in accordance with the 2009 NMFS BO under the No Action Alternative. Therefore, there would be no change in the amount of potentially suitable spawning and rearing habitat for spring-run Chinook Salmon (as indexed by WUA) available under Alternative 3 as compared to the No Action Alternative.

Changes in SALMOD Output

SALMOD results indicate that potential juvenile production would be similar under Alternative 3 and the No Action Alternative (Appendix 9D, Table B-3-6).

Changes in Delta Passage Model Output

The Delta Passage Model predicted similar estimates of annual Delta survival across the 81-year time period for spring-run Chinook Salmon between Alternative 3 and the No Action Alternative (Appendix 9J). Median Delta survival was 0.286 for Alternative 3 and 0.296 for the No Action Alternative.

Changes in Delta Hydrodynamics

Spring-run Chinook Salmon are most abundant in the Delta from March through May. Near the junction of Georgiana Slough, the median proportion of time that velocity would be positive was similar in March, April, and May under both alternatives (Appendix 9K). Near the confluence of the San Joaquin River and the Mokelumne River, the median proportion of positive velocities would be similar in March and slightly to moderately, lower under Alternative 3 relative to the No Action Alternative in April and May, respectively. A similar pattern was observed in the San Joaquin River downstream of the Head of Old River (Appendix 9K). In Old River upstream of the facilities, the median proportion of positive velocities would be slightly higher in April and May under Alternative 3 relative to the No Action Alternative and similar in March. In Old River downstream of the facilities, the median proportion of positive velocities would be similar in March and substantially lower in April and May under Alternative 3 relative to the No Action Alternative.

Changes in Junction Entrainment

Entrainment at Georgiana Slough would be similar under both alternatives during March, April and May, when spring-run Chinook Salmon are most abundant in the Delta (Appendix 9L). At the Head of Old River, median entrainment probabilities would be slightly greater under Alternative 3 during April and May, whereas probabilities would be similar in March. At the Turner Cut junction, median entrainment probabilities under Alternative 3 and the No Action Alternative would be similar in March. During April and May, entrainment probabilities would be more divergent with slightly higher values for Alternative 3 relative to the No Action Alternative. Overall, entrainment was slightly lower at the Columbia Cut junction relative to Turner Cut, but patterns of entrainment between these two alternatives would be similar with moderately higher values for median entrainment in April and May under Alternative 3. Patterns at the Middle River and Old River junctions would be similar to those observed at Columbia and Turner Cut junctions.

Changes in Salvage

Salvage of Sacramento River-origin Chinook Salmon is predicted to be similar under Alternative 3 and the No Action Alternative in every month except during April, May, and June (Appendix 9M). Spring-run Chinook Salmon smolts migrating through the Delta would be most susceptible in the months of March, April, and May. Predicted values in April and May indicated a substantially larger fraction of fish salvaged under Alternative 3 relative to the No Action Alternative. Predicted median salvage was similar in March under Alternative 3 and the No Action Alternative.

Summary of Effects on Spring-Run Chinook Salmon

The multiple model and analysis outputs described above characterize the anticipated conditions for spring-run Chinook Salmon and their response to change under Alternative 3 and the No Action Alternative. For the purpose of analyzing effects on spring-run Chinook Salmon in the Sacramento River, greater reliance was placed on the outputs from the SALMOD model because it integrates the available information on temperature and flows to produce estimates of mortality for each life stage and an overall, integrated estimate of potential spring-run Chinook Salmon juvenile production. The output from SALMOD indicated that spring-run Chinook Salmon production in the Sacramento River would be similar under Alternative 3 and the No Action Alternative.

The analyses attempting to assess the effects on routing, entrainment, and salvage of juvenile salmonids in the Delta suggest that salvage (as an indicator of potential losses of juvenile salmon at the export facilities) of Sacramento River-origin Chinook Salmon is predicted to be greater under Alternative 3 relative to the No Action Alternative.

In Clear Creek and the Feather River, the analysis of the effects of Alternative 3 and the No Action Alternative for spring-run Chinook Salmon relied on output from the WUA analysis and water temperature output for Clear Creek at Igo, and in the Feather River low flow channel and downstream of the Thermalito complex. The WUA analysis suggests that there would be little difference in the availability of spawning and rearing habitat in Clear Creek. The temperature model outputs suggest that thermal conditions and effects on each of the spring-run Chinook Salmon life stages generally would be similar under both scenarios in Clear Creek and the Feather River, although water temperatures could be somewhat less suitable for spring-run Chinook Salmon holding and spawning/egg incubation in the Feather River under Alternative 3. This conclusion is supported by the water temperature threshold exceedance analysis that indicated that water temperature thresholds for spawning and egg incubation would be exceeded slightly more frequently under Alternative 3 than under the No Action Alternative in Clear Creek and the Feather River. Because of the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), the slightly greater likelihood of exceeding water temperature thresholds under Alternative 3 could increase the potential for adverse effects on spring-run Chinook Salmon in the Feather River. Given the similarity of the results, Alternative 3 and the No Action Alternative are likely to have similar effects on the spring-run Chinook Salmon population in Clear Creek.

These model results suggest that overall, effects on spring-run Chinook Salmon could be slightly more adverse under Alternative 3 than under the No Action Alternative. The potential differences between the two scenarios, however, may be even larger due to the benefits of implementation of fish passage under the No Action Alternative intended to address the limited availability of suitable habitat for spring-run Chinook Salmon in the Sacramento River reaches downstream of Shasta Dam. This potential beneficial effect and its magnitude would depend on the success of the fish passage program. In addition, RPA actions intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities could improve the overall salvage survival of spring-run Chinook Salmon under the No Action Alternative.

The ocean harvest restriction component of Alternative 3 could increase spring-run Chinook Salmon numbers by reducing ocean harvest and the trap and haul program and predator control measures under Alternative 3 could reduce predation on juvenile spring-run Chinook Salmon and thereby increase survival.

Although the operational components associated with Alternative 3 could have greater adverse effects on spring-run Chinook Salmon than the No Action Alternative, the non-operational components associated with Alternative 3 could benefit spring-run Chinook Salmon relative to the No Action Alternative over the short term if successful. However, these measures would not address the long-term temperature challenges in the river downstream of Shasta Dam that would be addressed under the No Action Alternative if fish passage is successful. Even though the success of fish passage is uncertain, it is concluded that the potential for adverse effects on spring-run Chinook Salmon under Alternative 3 clearly would be greater than those under the No Action Alternative, principally because Alternative 3 does not include a strategy to address water temperatures critical to spring-run Chinook Salmon sustainability over the long term with climate change by 2030.

Fall-Run Chinook Salmon

Changes in operations that influence temperature and flow conditions in the Sacramento River downstream of Keswick Dam, Clear Creek downstream of Whiskeytown Dam, Feather River downstream of Oroville Dam and American River downstream of Nimbus could affect fall-run Chinook Salmon. The following describes those changes and their potential effects.

Changes in Water Temperature

Changes in water temperature could affect fall-run Chinook Salmon in the Sacramento, Feather, and American rivers, and Clear Creek. The following describes temperature conditions in those water bodies.

Sacramento River

Average monthly water temperature in the Sacramento River at Keswick Dam under Alternative 3 relative to the No Action Alternative generally would be similar (less than 0.5°F differences) water temperatures under the No Action Alternative during most months of the year (Appendix 6B, Table B-5-2). In September, average water temperatures in wetter years could be increased by up to 0.8°F and decreased by up to 1.2°F in critical years. A similar temperature pattern generally would be exhibited downstream at Ball's Ferry, Jelly's Ferry, Bend Bridge, Red Bluff, Hamilton City, and Knights Landing, with average monthly temperatures progressively increasing in the downstream direction (e.g., average difference in September of about 9°F between Keswick Dam and Knights Landing). The water temperature differences between Alternative 3 and the No Action Alternative in September of wetter years would increase to as high as 4.4°F warmer under Alternative 3 at Knight's Landing, while the differences in water temperatures in September associated with Alternative 3 during drier years would remain similar to upstream locations.

Overall, the water temperature differences between Alternative 3 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on fall-run Chinook Salmon in the Sacramento River. The increased water temperatures in September of wetter years under Alternative 3 could increase the likelihood of adverse effects on early spawning fall-run Chinook Salmon during this water year type. The slightly lower water temperatures in September of drier years under Alternative 3 would reduce the likelihood of adverse effects on early spawning fall-run Chinook Salmon in the Sacramento River as compared to the No Action Alternative.

Clear Creek

Average monthly water temperatures in Clear Creek at Igo under Alternative 3 would be similar to (less than 0.5°F differences) water temperatures under the No Action Alternative with the exception of May when average monthly temperatures under Alternative 3 would be somewhat higher (up to about 0.8°F) than the No Action Alternative (Appendix 6B, Table B-3-2). Alternative 32). As described above for spring-run Chinook Salmon, the lower water temperatures in May associated with the No Action Alternative reflect the effects of the additional water that would be discharged from Whiskeytown Dam to meet the 2009 NMFS BO RPA spring attraction flow requirements.

Under Alternative 3, temperature conditions at Igo would be similar to water temperatures under the No Action Alternative. However, these temperature outputs are at a location upstream of most fall-run Chinook Salmon spawning and rearing in Clear Creek. Temperatures where fall-run Chinook Salmon inhabit the creek would be somewhat higher as indicated by average monthly temperatures at the confluence with the Sacramento River, although these temperatures would be similar under Alternative 3 and the No Action Alternative. Overall, effects on fall-run Chinook Salmon in Clear Creek due to temperature differences between Alternative 3 and the No Action Alternative would be relatively minor.

Feather River

Average monthly water temperatures in the Feather River at the low flow channel under the Alternative 3 relative generally would be similar (within 0.5°F) to water temperatures under the No Action Alternative generally would be, except in November and December (differences as much as 1.6°F lower in December in below normal water years) (Appendix 6B, Table B-20-2). In September average monthly water temperatures under Alternative 3 could be somewhat higher (up to about 1.5°F) in wetter years than under the No Action Alternative. Although temperatures in the river would become progressively higher in the downstream direction, the differences between Alternative 3 and the No Action Alternative would exhibit a similar pattern at the downstream locations (Robinson Riffle and Gridley Bridge), with temperatures under Alternative 3 and the No Action Alternative generally becoming more similar at the confluence with the Sacramento River, except in September when water temperatures under Alternative 3 could be up to 4.4 °F higher than under the No Action Alternative and in June when temperatures under Alternative 3 could be up to 0.8°F cooler in drier years.

Overall, the temperature differences in the Feather River between Alternative 3 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on fall-run Chinook Salmon in the Feather River. The somewhat lower water temperatures in November and December under Alternative 3 would likely have little effect on fall-run Chinook Salmon as water temperatures in the Feather River are typically low during this time period. The somewhat higher water temperatures in September of wetter years may increase the likelihood of adverse effects on early spawning fall-run Chinook Salmon in these water year types.

American River

Long term average monthly water temperatures in the American River at Nimbus Dam under Alternative 3 generally would be similar (differences less than 0. 5°F) to those under the No Action Alternative (Appendix 6B, Table B-12-2). This pattern generally would persist downstream to Watt Avenue and the mouth although the temperature differences between scenarios would increase in June and September (Appendix 6B, Tables b-13-2 and B-13-2 and B-14-2). In June water temperatures could be up to 0.7°F lower under Alternative 3 than under the No Action Alternative in some water year types. In September, average monthly water temperatures at the mouth generally would be higher under Alternative 3 than under the No Action Alternative, especially in wetter water year types when the water temperatures under Alternative 3 could be up to 1.6°F warmer.

Overall, the temperature differences in the American River between Alternative 3 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on fall-run Chinook Salmon in the American River. The lower water temperatures in June under Alternative 3 may reduce the likelihood of adverse effects on fall-run Chinook Salmon rearing in the American River if they were present. Higher water temperatures during September under Alternative 3 would have little effect on fall-run Chinook Salmon spawning in the American River because most spawning occurs later in November.

Changes in Exceedances of Water Temperature Thresholds

Changes in water temperature could result in the exceedance of water temperatures that are protective of fall-run Chinook Salmon in the Sacramento River, Clear Creek, Feather River, and American River. The following describes the extent of those exceedances for each of those water bodies.

Sacramento River

Average monthly water temperatures under both Alternative and the No Action Alternative would show exceedances of the water temperature threshold of 56°F established in the Sacramento River at Red Bluff for fall-run Chinook Salmon (spawning and egg incubation) in October, November, and again in April. The exceedances would occur at the greatest frequency in October (78 percent of the time under Alternative 3). The water temperature threshold would be exceeded less frequently in November (8 percent of the time) and not exceeded at all during December through March under Alternative 3. As water temperatures warm in the spring, the threshold would be exceeded in April by 14 percent under Alternative 3. In the months when the greatest frequency of exceedances occur (October, November, and April), model results generally indicate that the threshold would be exceeded less frequently (by up to 4 percent in October) under Alternative 3 than under the No Action Alternative. Temperature conditions in the Sacramento River under Alternative 3 could be less likely to affect fall-run Chinook Salmon spawning and egg incubation than under the No Action Alternative because of the decreased frequency of exceedance of the 56°F threshold in October, November, and April.

Clear Creek

Fall-run Chinook Salmon spawning in lower Clear Creek typically occurs during October through December (USFWS 2015). Average monthly water temperatures at Igo during this period generally remain below 56°F, except in October. Under Alternative 3, 56°F would be exceeded in October about 10 percent of the time as compared to 12 percent under the No Action Alternative.

At the confluence with the Sacramento River, average monthly water temperatures would be warmer, with 56°F exceeded about 15 percent of the time under Alternative 3 and slightly more frequently under the No Action Alternative (Appendix 6B, Figure B-4-1). During November and December, average monthly water temperatures generally would remain below 56°F at both locations. Temperature conditions in Clear Creek under Alternative 3 could be less likely to affect fall-run Chinook Salmon spawning and egg incubation than under the No Action Alternative because of the reduced frequency of exceedance of the 56°F threshold in October.

For fall-run Chinook Salmon rearing (January through August), the exceedances described previously for spring-run Chinook Salmon would apply, with the average monthly temperatures remaining below the 60°F threshold in all months Downstream at the mouth of Clear Creek, average monthly water temperatures would exceed the 60°F threshold often during the summer, but the frequency of exceedance would be similar under Alternative 3 and the No Action Alternative (Appendix 6B Figures). Temperature conditions for fall-run Chinook Salmon rearing in Clear Creek would be similar under Alternative 3 and the No Action Alternative.

Feather River

Average monthly water temperatures under both Alternative 3 and the No Action Alternative would exceed the water temperature threshold of 56°F established in the Feather River at Gridley Bridge for fall-run Chinook Salmon spawning and rearing during some months, particularly in October, November, March, and April, when temperature thresholds would be exceeded frequently (Appendix 9N). The frequency of exceedance would be greatest in October, when average monthly temperatures under both Alternative 3 and the No Action Alternative would be above the threshold in nearly every year. The magnitude of the exceedances would be high as well, with average monthly temperatures in October reaching about 68°F. Similarly, the threshold would be exceeded under both alternatives about 85 percent of the time in April. However, water temperatures under Alternative 3 could exceed temperature thresholds about 1-4 percent less frequently than under the No Action Alternative. Temperature conditions in the Feather River under Alternative 3 could be less likely to affect fall-run Chinook Salmon spawning and egg incubation than under the No Action Alternative because of the reduced frequency of exceedance of the 56°F threshold from October through April.

Changes in Egg Mortality

The analysis of fall-run Chinook Salmon included the application of the Reclamation Salmon Survival Model. The following describes the differences in egg mortality for the Sacramento, Feather, and American rivers based on the model output.

Sacramento River

For fall-run Chinook Salmon in the Sacramento River, the long-term average egg mortality rate is predicted to be around 17 percent, with higher mortality rates (in excess of 35 percent) occurring in critical dry years under Alternative 3. Overall, egg mortality would similar under Alternative 3and the No Action Alternative in all water year types (Appendix 9C, Table B-1).

Feather River

For fall-run Chinook Salmon in the Feather River, the long-term average egg mortality rate is predicted to be relatively low (around 6 percent), with higher mortality rates (around 14.6 percent) occurring in critical dry years under Alternative 3. Overall, egg mortality would be similar under Alternative 3 and the No Action Alternative in all water year types (Appendix 9C, Table B-7).

American River

For fall-run Chinook Salmon in the American River, the long-term average egg mortality rate is predicted to range from approximately 22 to 25 percent in all water year types under Alternative 3. Overall, egg mortality would be 0similar under Alternative 3 and the No Action Alternative in all water year types (Appendix 9C, Table B-6).

Changes in Weighted Usable Area

Weighted usable area, which is influenced by flow, is a measure of habitat suitability. The following describes changes in WUA for fall-run Chinook Salmon in the Sacramento, Feather, and American rivers and Clear Creek.

Sacramento River

As an indicator of the amount of suitable spawning habitat for fall-run Chinook Salmon between Keswick Dam and Battle Creek, modeling results indicate that, in general, there would be greater amounts of spawning habitat available from September and November under Alternative 3 as compared to the No Action Alternative; fall-run spawning WUA would be similar in October and December (Appendix 9E, Table C-11-2). The increase in long-term average spawning WUA in September under Alternative 3 (prior to the peak spawning period) would be relatively large (around 20 percent), with a smaller increase in November (around 15 percent) which comprises the peak spawning period for fall-run Chinook Salmon. Results for the reach from Battle Creek to Deer Creek show the same pattern in changes in WUA for spawning fall-run Chinook Salmon between Alternative 3 and the No Action Alternative (Appendix 9E, Table C-10-2). Overall, spawning habitat availability could be increased under Alternative 3 relative to the No Action Alternative.

Modeling results indicate that, in general, there would be similar amounts of suitable fry rearing habitat available from December to March under Alternative 3 (Appendix 9E, Table C-12-2). Similar to the results for fry rearing WUA, modeling results indicate that, there would be similar amounts of suitable juvenile rearing habitat available during the juvenile rearing period from February to June (Appendix 9E, Table C-13-2).

Clear Creek

Flows in Clear Creek below Whiskeytown Dam are not anticipated to differ under Alternative 3 relative to the No Action Alternative except in May due to the release of spring attraction flows in accordance with the 2009 NMFS BO under the No Action Alternative. Therefore, there would be no change in the amount of potentially suitable spawning and rearing habitat for fall-run Chinook Salmon (as indexed by WUA) available under Alternative 3 as compared to the No Action Alternative.

Feather River

Flows in the low flow channel of the Feather River are not anticipated to differ under Alternative 3 relative to the No Action Alternative. Therefore, there would be no change in the amount of potentially suitable spawning habitat for fall-run Chinook Salmon (as indexed by WUA) available under Alternative 3 as compared to the No Action Alternative. The majority of spawning activity by fall-run Chinook Salmon in the Feather River occurs in this reach with a lesser amount of spawning occurring downstream of the Thermalito Complex.

Modeling results indicate that, in general, there would be greater amounts of spawning habitat available in September under Alternative 3 as compared to the No Action Alternative. The increase in long-term average spawning WUA during September (prior to the peak spawning period) would be relatively large (around 30 percent), with similar amounts of spawning WUA for fall-run Chinook Salmon predicted during other months. Overall, spawning habitat availability would be somewhat similar under Alternative 3 relative to the No Action Alternative.

American River

Modeling results indicate that, in general, there would be similar amounts of spawning habitat available for fall-run Chinook Salmon in the American River from October to December under Alternative 3 as compared to the No Action Alternative (Appendix 9E, Table C-25-2).

Changes in SALMOD Output

SALMOD results indicate that potential juvenile production would be similar under Alternative 3 and the No Action Alternative, but up to 5 percent greater under Alternative 3 in critical dry years.

Changes in Delta Passage Model Output

The Delta Passage Model predicted similar estimates of annual Delta survival across the 81-year time period for fall-run Chinook Salmon between Alternative 3 and the No Action Alternative (Appendix 9J). Median Delta survival was 0.246 for Alternative 3 and 0.245 for the No Action Alternative.

Changes in Delta Hydrodynamics

Fall-run Chinook Salmon smolts are most abundant in the Delta during the months of April, May and June. At the junction of Georgiana Slough and the Sacramento River, the median proportion of positive velocities would be similar in April, May and June under Alternative 3 and the No Action Alternative (Appendix 9K). Near the confluence of the San Joaquin River and the

Mokelumne River, the median proportion of positive velocities would be slightly lower under Alternative 3 relative to the No Action Alternative in April and May and similar in June. On Old River downstream of the facilities, the median proportion of positive velocities would be substantially lower in April and May under Alternative 3 relative to the No Action Alternative, but would be only moderately lower in June. In Old River upstream of the facilities, the median proportion of positive velocities would be similar for Alternative 3 relative to the No Action Alternative in June. In April and May, values for Alternative 3 would be slightly higher under Alternative 3 relative to the No Action Alternative. On the San Joaquin River downstream of the Head of Old River, the median proportion of positive velocities would be similar under Alternative 3 relative to the No Action Alternative in April, May, and June.

Changes in Junction Entrainment

The median entrainment at Georgiana Slough under Alternative 3 would be slightly greater in June relative to the No Action Alternative (Appendix 9L). In April and May, median entrainment would be almost identical under both alternatives. At the Head of Old River junction, entrainment under Alternative 3 would be slightly higher in April, May, and June relative to the No Action Alternative. Median entrainment into Turner Cut would be slightly greater under Alternative 3 during April, and May and similar in June. At the Columbia Cut junction, entrainment would be moderately higher under Alternative 3 during April and May, whereas entrainment would be slightly higher in June. Entrainment probabilities at the Middle River junction from April through June would be moderately greater under Alternative 3 relative to the No Action Alternative. A similar pattern would be observed at the Old River junction.

Changes in Salvage

Salvage of Sacramento River-origin Chinook Salmon is predicted to be similar under Alternative 3 and No Action Alternative in every month except April, May, and June (Appendix 9M). Fall-run Chinook Salmon smolts migrating through the Delta would be most susceptible in the months of April, May, and June. Predicted values in April and May indicated a substantially increased fraction of fish salvaged under Alternative 3 relative to the No Action Alternative and a moderately increased fraction salvaged in June under Alternative 3.

Summary of Effects on Fall-Run Chinook Salmon

The multiple model and analysis outputs described above characterize the anticipated conditions for fall-run Chinook Salmon and their response to change under Alternative 3 and the No Action Alternative. For the purpose of analyzing effects on fall-run Chinook Salmon in the Sacramento River, greater reliance was placed on the outputs from the SALMOD model because it integrates the available information on temperature and flows to produce estimates of mortality for each life stage and an overall, integrated estimate of potential fall-run Chinook Salmon juvenile production. The output from SALMOD indicated that fall-run Chinook Salmon production would be similar in most water year types under Alternative 3 and the No Action Alternative, but up to 5 percent greater under Alternative 3 than under the No Action Alternative in critical dry years.

The analyses attempting to assess the effects on routing, entrainment, and salvage of juvenile salmonids in the Delta suggest that salvage (as an indicator of potential losses of juvenile salmon at the export facilities) of Sacramento River-origin Chinook Salmon is predicted to be greater under Alternative 3 relative to the No Action Alternative.

In Clear Creek and the Feather and American rivers, the analysis of the effects of Alternative 3 and the No Action Alternative for fall-run Chinook Salmon relied on the WUA analysis for habitat and water temperature model output for the rivers at various locations downstream of the CVP and SWP facilities. The WUA analysis indicated that the availability of spawning and rearing habitat in Clear Creek and spawning habitat in the Feather and American rivers would be similar under Alternative 3 and the No Action Alternative. The temperature model outputs for each of the fall-run Chinook Salmon life stages suggest that thermal conditions and effects on fall-run Chinook Salmon in all of these streams generally would be similar under both scenarios. The water temperature threshold exceedance analysis that indicated that the water temperature thresholds for fall-run Chinook Salmon spawning and egg incubation would be exceeded slightly less frequently in the Feather River and Clear Creek under Alternative 3 and could reduce the potential for adverse effects on the fall-run Chinook Salmon populations in Clear Creek and the Feather River. Results of the analysis using Reclamation’s salmon mortality model indicate that there would be slightly reduced fall-run Chinook Salmon egg mortality in the Feather River under Alternative 3 compared to the No Action Alternative.

These model results suggest that overall, effects on fall-run Chinook Salmon could be slightly less adverse under Alternative 3 than the No Action Alternative. This potential distinction between the two scenarios, however, may be partially offset by the benefits of implementation of fish passage under the No Action Alternative intended to address the limited availability of suitable habitat for winter-run and spring-run Chinook Salmon in the Sacramento River reaches downstream of Keswick Dam. This potential benefit, however, would only apply if passage is provided for fall-run Chinook Salmon that allows access to additional habitat. In addition, RPA actions under the No Action Alternative intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities could improve the overall salvage survival of fall-run Chinook Salmon. The ocean harvest restriction component of Alternative 3 could increase fall-run Chinook Salmon numbers by reducing ocean harvest and the trap and haul program and predator control measures under Alternative 3 could reduce predation on juvenile fall-run Chinook Salmon and thereby increase survival.

Overall, the results of the numerical models suggest the potential for less adverse effects on fall-run Chinook Salmon under Alternative 3 as compared to the No Action Alternative. However, discerning a meaningful difference between these two scenarios based on the quantitative results is not possible because of the similarity in results (generally differences less than 5 percent) and the inherent uncertainty of the models. In addition, adverse effects of the No Action Alternative could be offset by the potentially beneficial effects resulting from the

RPA actions evaluated qualitatively for the No Action Alternative. Adverse effects of Alternative 3 could be offset by the potentially beneficial effects resulting from predator control and ocean harvest restrictions. Thus, it is concluded that the effects on fall-run Chinook Salmon would be similar under Alternative 3 and the No Action Alternative.

Late Fall-Run Chinook Salmon

Changes in operations that influence temperature and flow conditions in the Sacramento River downstream of Keswick Dam could affect late fall-run Chinook Salmon. The following describes those changes and their potential effects.

Changes in Water Temperature

Average monthly water temperature in the Sacramento River at Keswick Dam under Alternative 3 relative to the No Action Alternative generally would be similar to (less than 0.5°F differences) water temperatures under the No Action Alternative during most months of the year (Appendix 6B, Table B-5-2). In September, average water temperatures in wetter years could be increased by up to 0.8°F and decreased by up to 1.2°F in critical years. A similar temperature pattern generally would be exhibited downstream at Ball’s Ferry, Jelly’s Ferry, Bend Bridge, Red Bluff, Hamilton City, and Knights Landing, with average monthly temperatures progressively increasing in the downstream direction (e.g., average difference in September of about 9°F between Keswick Dam and Knights Landing). The temperature differences between Alternative 3 and the No Action Alternative in September of wetter years would increase to as high as 4.4°F warmer under Alternative 3 at Knight’s Landing, while the differences in water temperatures in September associated with Alternative 3 during drier years would remain similar to upstream locations.

Overall, the temperature differences between Alternative 3 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on late fall-run Chinook Salmon in the Sacramento River. The likelihood of adverse effects on late fall-run Chinook Salmon spawning and egg incubation would be similar under Alternative 3 and the No Action Alternative due to similar water temperatures during the January to May time period. Because late fall-run Chinook Salmon have an extended rearing period, the similar water temperatures during the summer under Alternative 3 and the No Action Alternative would have similar effects on rearing fry and juvenile late fall-run Chinook Salmon in the Sacramento River. The slightly higher water temperatures under Alternative 3 in September of wetter years may increase the likelihood of adverse effects on fry and juvenile late fall-run Chinook Salmon rearing in the Sacramento River during this limited time period.

Changes in Exceedances of Water Temperature Thresholds

Average monthly water temperatures under both Alternative and the No Action Alternative would show exceedances of the water temperature threshold of 56°F established in the Sacramento River at Red Bluff for Chinook Salmon (spawning and egg incubation) in October, November, and again in April. The exceedances would occur at the greatest frequency in October (78 percent of the time under

Alternative 3). The water temperature threshold would be exceeded less frequently in November (8 percent of the time) and not exceeded at all during December through March under Alternative 3. As water temperatures warm in the spring, the threshold would be exceeded in April by 14 percent under Alternative 3. In the months when the greatest frequency of exceedances occur (October, November, and April), model results generally indicate that the threshold would be exceeded less frequently (by up to 4 percent in October) under Alternative 3 than under the No Action Alternative. Temperature conditions in the Sacramento River under Alternative 3 could be less likely to affect late fall-run Chinook Salmon spawning and egg incubation than under the No Action Alternative because of the decreased frequency of exceedance of the 56°F threshold in October, November, and April.

Changes in Egg Mortality

For late fall-run Chinook Salmon in the Sacramento River, the long-term average egg mortality rate is predicted to range from approximately 1.8 to nearly 5 percent in all water year types under Alternative 3. Overall, egg mortality would be similar under Alternative 3 and the No Action Alternative (Appendix 9C, Table B-2) in all water year types.

Changes in Weighted Usable Area

Modeling results indicate that there would be similar amounts of spawning habitat available for late fall-run Chinook Salmon in the Sacramento River from January through April under Alternative 3 as compared to the No Action Alternative (Appendix 9E, Table C-14-4).

Modeling results indicate that, in general, there would be similar amounts of suitable late fall-run Chinook Salmon fry rearing habitat available during April and May under Alternative 3 and the No Action Alternative (Appendix 9E, Table C-15-4).

A substantial fraction of late fall run Chinook Salmon juveniles oversummer in the Sacramento River before emigrating, which allows them to avoid predation through both their larger size and greater swimming ability. One implication of this life history strategy is that rearing habitat is most likely the limiting factor for late-fall-run Chinook Salmon, especially if availability of cool water determines the downstream extent of spawning habitat for late-fall-run salmon. Modeling results indicate that, there would generally be similar amounts of suitable juvenile rearing habitat available from December through August under Alternative 3 and the No Action Alternative. There could an increase in the amount of late fall-run Chinook Salmon juvenile rearing WUA in September and November of up to nearly 10 percent (Appendix 9E, Table C-16-4). Overall, late fall-run juvenile rearing habitat availability would be similar under Alternative 3 and the No Action Alternative.

Changes in SALMOD Output

SALMOD results indicate that potential juvenile production would be the same under Alternative 3 and the No Action Alternative (Appendix 9D, Table B-2-6).

Changes in Delta Passage Model Output

For late fall-run Chinook Salmon, Delta survival was predicted to be slightly lower for Alternative 3 versus the No Action Alternative for all 81 years simulated by the Delta Passage Model (Appendix 9J). Median Delta survival across all years was 0.199 for Alternative 3 and 0.244 for the No Action Alternative.

Changes in Delta Hydrodynamics

The late fall-run Chinook Salmon migration period overlaps with the winter-run. See the section on hydrodynamic analysis for winter-run Chinook Salmon for potential effects on late fall-run Chinook Salmon.

Changes in Junction Entrainment

Entrainment probabilities for late fall-run Chinook Salmon are assumed to mimic that of winter-run Chinook Salmon due to the overlap in timing. See the section on winter-run Chinook Salmon entrainment for potential effects on late fall-run Chinook Salmon.

Changes in Salvage

Salvage of late fall-run Chinook Salmon is assumed to mimic that of winter-run Chinook Salmon due to the overlap in timing. See the section on winter-run Chinook Salmon entrainment for potential effects on late fall-run Chinook Salmon.

Summary of Effects on Late Fall-Run Chinook Salmon

The multiple model and analysis outputs described above characterize the anticipated conditions for late fall-run Chinook Salmon and their response to change under Alternative 3 and the No Action Alternative. For the purpose of analyzing effects on late fall-run Chinook Salmon and developing conclusions, greater reliance was placed on the outputs from the SALMOD model because it integrates the available information on temperature and flows to produce estimates of mortality for each life stage and an overall, integrated estimate of potential fall-run Chinook Salmon juvenile production. The output from SALMOD indicated that late fall-run Chinook Salmon production would be similar under Alternative 3 and the No Action Alternative.

The analyses attempting to assess the effects on routing, entrainment, and salvage of juvenile salmonids in the Delta suggest that salvage (as an indicator of potential losses of juvenile salmon at the export facilities) of Sacramento River-origin Chinook Salmon is predicted to be similar under Alternative 3 relative to the No Action Alternative. Actions under the No Action Alternative intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities could improve the overall salvage survival of late fall-run Chinook Salmon.

Overall, the results of the numerical models suggest that potential effects on late fall-run Chinook Salmon would be similar for Alternative 3 and the No Action Alternative. Discerning a meaningful difference between these two scenarios based on the quantitative results is not possible because of the similarity in results (generally differences less than 5 percent) and the inherent uncertainty of the models. Because fish passage under the No Action Alternative is not expected to directly benefit late fall-run Chinook Salmon, the non-operational actions intended to benefit salmonids under both alternatives are expected to balance. Thus, it is concluded that the effects on late fall-run Chinook Salmon would be similar under Alternative 3 and the No Action Alternative.

Steelhead

Changes in operations that influence temperature and flow conditions that could affect steelhead. The following describes those changes and their potential effects.

Changes in Water Temperature

Changes in water temperature could affect steelhead in the Sacramento, Feather, and American rivers, and Clear Creek. The following describes temperature conditions in those water bodies.

Sacramento River

Average monthly water temperature in the Sacramento River at Keswick Dam under Alternative 3 relative to the No Action Alternative generally would be similar (less than 0.5°F differences) water temperatures under the No Action Alternative during most months of the year (Appendix 6B, Table B-5-2). In September, average water temperatures in wetter years could be increased by up to 0.8°F and decreased by up to 1.2°F in critical years. A similar temperature pattern generally would be exhibited downstream at Ball’s Ferry, Jelly’s Ferry, Bend Bridge, and Red Bluff, with average monthly temperatures progressively increasing in the downstream direction (e.g., average difference of about 3°F between Keswick Dam and Red Bluff). The water temperature differences between Alternative 3 and the No Action Alternative in September of wetter years would increase to as high as 3.0°F warmer under Alternative 3 at Red Bluff, while the differences in water temperatures in September associated with Alternative 3 during drier years would remain similar to upstream locations.

Overall, the water temperature differences between Alternative 3 and the No Action Alternative would be relatively (less than 0.5°F) minor and likely would have little effect on steelhead in the Sacramento River. The increased water temperatures in September of wetter years under Alternative 3 could increase the likelihood of adverse effects on migrating adult steelhead during this water year type. The slightly lower water temperatures in September of drier years under Alternative 3 could reduce the likelihood of adverse effects on migrating adult steelhead during drier years as compared to the No Action Alternative.

Clear Creek

Average monthly water temperatures in Clear Creek at Igo under Alternative 3 would be similar to (less than 0.5°F differences) water temperatures under the No Action Alternative with the exception of May when average monthly temperatures under Alternative 3 would be somewhat higher (up to about 0.8°F) than the No Action Alternative. As described above for spring-run Chinook

Salmon, the lower water temperatures in May associated with the No Action Alternative reflect the effects of the additional water that would be discharged from Whiskeytown Dam to meet the 2009 NMFS BO RPA spring attraction flow requirements. Overall, thermal conditions for steelhead in Clear Creek would be similar under Alternative 3 and the No Action Alternative.

Feather River

Average monthly water temperatures in the Feather River at the low flow channel under the Alternative 3 relative generally would be similar (within 0.5°F) to water temperatures under the No Action Alternative except in November and December (differences as much as 1.6°F in December in below normal water years) (Appendix 6B, Table B-20-2). In September average monthly water temperatures under Alternative 3 could be somewhat higher (up to about 1.5°F) in wetter years than under the No Action Alternative. Although temperatures in the river would become progressively higher in the downstream direction, the differences between Alternative 3 and the No Action Alternative would exhibit a similar pattern at the downstream locations (Robinson Riffle and Gridley Bridge), with temperatures under Alternative 3 and the No Action Alternative generally becoming more similar among months at the confluence with the Sacramento River, except in September when water temperatures under Alternative 3 could be up to 4.4 °F higher than under the No Action Alternative and in June when temperatures under Alternative 3 could be up to 0.8°F cooler in drier years.

Overall, the temperature differences in the Feather River between Alternative 3 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on steelhead in the Feather River. The somewhat higher water temperatures in September of wetter years may increase the likelihood of adverse effects on migrating adult steelhead during this water year type. The somewhat lower water temperatures in in November and December under Alternative 3 also could reduce the likelihood of adverse effects on steelhead adults migrating upstream and juveniles migrating downstream in the Feather River as compared to the No Action Alternative.

American River

Long term average monthly water temperatures in the American River at Nimbus Dam under Alternative 3 generally would be similar (differences less than 0.5°F) to those under the No Action Alternative (Appendix 6B, Table B-12-2). This pattern generally would persist downstream to Watt Avenue and the mouth, although the temperature differences between scenarios would increase in June and September (Appendix 6B, Tables B-13-2 and B-13-2 and B-14-2). In June water temperatures could be up to 0.7°F lower under Alternative 3 than under the No Action Alternative in some water year types. In September, average monthly water temperatures at the mouth generally would be higher under Alternative 3 than under the No Action Alternative, especially in wetter water year types when the water temperatures under Alternative 3 could be up to 1.6°F warmer.

Overall, the temperature differences between Alternative 3 and the No Action Alternative would be minor (less than 0.5°F) and likely would have little effect on steelhead in the American River. The somewhat higher water temperatures in September of wetter years may increase the likelihood of adverse effects on migrating adult steelhead during this water year type. The cooler water temperatures in June under Alternative 3 may reduce the likelihood of adverse effects on steelhead rearing in the American River compared to the No Action Alternative.

Changes in Exceedances of Water Temperature Thresholds

Changes in water temperature could result in the exceedance of established water temperature thresholds for steelhead in the Sacramento River, Clear Creek, and Feather River. The following describes the extent of those exceedance for each of those streams.

Sacramento River

As described in the life history accounts, steelhead spawning in the mainstem Sacramento River generally occurs in the upper reaches from Keswick Dam downstream to near Balls Ferry, with most spawning concentrated near Redding. Most steelhead, however, spawn in tributaries to the Sacramento River. Spawning generally takes place in the January through March period when water temperatures in the river generally do not exceed 52°F under either Alternative 3 or the No Action Alternative. While there are no established temperature thresholds for steelhead rearing in the mainstem Sacramento River, average monthly temperatures when fry and juvenile steelhead are in the river would generally remain below 56°F at Balls Ferry except in August and September when this temperature would be exceeded 30 to 40 percent of the time under both Alternative 3 and the No Action Alternative. However, water temperatures in the Sacramento River at Balls Ferry would exceed 56°F about 10 percent more often in September under Alternative 3. Overall, thermal conditions for steelhead in the Sacramento River would be more likely to result in adverse effects on steelhead under Alternative 3 than under the No Action Alternative because of the increased frequency of exceedance of 56°F in September.

Clear Creek

While there are no established temperature thresholds for steelhead spawning in Clear Creek, average monthly water temperatures in the river generally would not exceed 49°F during the spawning period (December to April) under Alternative 3 and the No Action Alternative. Similarly, while there are no established temperature thresholds for steelhead rearing in Clear Creek, average monthly temperatures in most months of the year would not exceed 56°F at Igo under both alternatives. Overall, thermal conditions for steelhead in Clear Creek would be similar under Alternative 3 and the No Action Alternative.

Feather River

Average monthly water temperatures in the Feather River at Robinson Riffle would on occasion exceed the water temperature threshold of 56°F established for steelhead spawning and incubation during some months, particularly in October and November, and March and April, when temperature thresholds could be exceeded frequently (Appendix 9N). There would be a 1 percent exceedance of the 56°F threshold in December under the No Action Alternative and no exceedances of the 56°F threshold from December through February under Alternative 3. However, the differences in the frequency of exceedance between Alternative 3 and No Action Alternative during March and April would be relatively small with water temperatures under Alternative 3 exceeding the threshold about 1 percent more frequently in March (19 percent) and the same exceedance frequency (75 percent) as the No Action Alternative in April.

The established water temperature threshold of 63°F for rearing during May through August would be exceeded often under both Alternative 3 and the No Action Alternative in May and June, but not at all in July and August. Water temperatures under Alternative 3 would exceed the rearing temperature threshold about 5 percent less frequently than under the No Action Alternative in May, but no more frequently in June. Temperature conditions in the Feather River under Alternative 3 could be less likely to affect steelhead spawning and rearing than under the No Action Alternative because of the reduced frequency of exceedance of the spawning and rearing thresholds.

American River

In the American River, the water temperature threshold for steelhead rearing (May through October) is 65°F at the Watt Avenue Bridge. Average monthly water temperatures would exceed this threshold often under both Alternative 3 and the No Action Alternative, especially in the July through September period when the threshold is exceeded nearly all of the time. In addition, the magnitude of the exceedance would be high, with average monthly water temperatures sometimes higher than 76°F. The differences between Alternative 3 and No Action Alternative, however, would be relatively small (differences within 2 percent), except in September, when water temperatures under Alternative 3 would exceed 65°F about 7 percent more frequently than under the No Action Alternative. Temperature conditions in the American River under Alternative 3 could be more likely to affect steelhead rearing than under the No Action Alternative because of the increased frequency of exceedance of the 65°F rearing threshold.

Changes in Weighted Usable Area

The following describes changes in WUA for steelhead in the Sacramento, Feather, and American rivers and Clear Creek.

Sacramento River

Modeling results indicate that, in general, there would be similar amounts of suitable steelhead spawning habitat available from December through March under Alternative 3 as compared to the No Action Alternative (Appendix 9E, Table C-20-2).

Clear Creek

Flows in Clear Creek below Whiskeytown Dam are not anticipated to differ under Alternative 3 relative to the No Action Alternative except in May due to the release of spring attraction flows in accordance with the 2009 NMFS BO under the No Action Alternative. Therefore, there would be no change in the amount of potentially suitable spawning and rearing habitat for steelhead (as indexed by WUA) available under Alternative 3 as compared to the No Action Alternative.

Feather River

Flows in the low flow channel of the Feather River are not anticipated to differ under Alternative 3 relative to the No Action Alternative. Therefore, there would be no change in the amount of potentially suitable spawning habitat for steelhead (as indexed by WUA) available under Alternative 3 as compared to the No Action Alternative. The majority of spawning activity by steelhead in the Feather River occurs in this reach with a lesser amount of spawning occurring downstream of the Thermalito Complex.

Modeling results indicate that, in general, there would be similar amounts of spawning habitat for steelhead in the Feather River below Thermalito available from December through April under Alternative 3 and the No Action Alternative.

American River

Modeling results indicate that, in general, there would be similar amounts of spawning habitat for steelhead in the American River downstream of Nimbus Dam available from December through April under Alternative 3 and the No Action Alternative.

Summary of Effects on Steelhead

The multiple model and analysis outputs described above characterize the anticipated conditions for steelhead and their response to change under Alternative 3 and the No Action Alternative. The analysis of the effects of Alternative 3 and the No Action Alternative for steelhead relied on the WUA analysis for habitat and water temperature model output for the rivers at various locations downstream of the CVP and SWP facilities. The WUA analysis indicated that the availability of steelhead spawning and rearing habitat in Clear Creek and steelhead spawning habitat in the Sacramento, Feather and American rivers would be similar under Alternative 3 and the No Action Alternative. The temperature model outputs for each of the steelhead life stages suggest that thermal conditions and effects on steelhead could be slightly less adverse for some life stages in various rivers under Alternative 3. This conclusion is supported by the water temperature threshold exceedance analysis that indicated that the water temperature thresholds for steelhead spawning and egg incubation would be exceeded less frequently in the Feather River under Alternative 3. The water temperature threshold for steelhead rearing would also be exceeded less frequently in the Feather River. However, the water temperature threshold for steelhead rearing in the American River would be exceeded more frequently under Alternative 3 than under the No Action Alternative. The reduced frequency of exceedance of temperature thresholds under Alternative 3 could reduce the potential for adverse effects on the steelhead population in the Feather River while the increased frequency of exceedance could increase the likelihood of adverse effects on steelhead rearing in the American River.

These model results suggest that overall, effects on steelhead could be slightly less adverse under Alternative 3 than the No Action Alternative, particularly in the Feather River. Implementation of the fish passage program under the No Action Alternative intended to address the limited availability of suitable habitat for steelhead in the Sacramento and American river could provide a benefit to Central Valley steelhead in the Sacramento and American rivers. This is particularly important in light of anticipated increases in water temperature associated with climate change in 2030. In addition to fish passage, preparation and implementation of an HGMP for steelhead at the Nimbus Fish Hatchery and actions under the No Action Alternative intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities could benefit steelhead under the No Action Alternative in comparison to Alternative 3. Thus, on balance and over the long term, the adverse effects on steelhead under Alternative 3 would be greater than those under the No Action Alternative.

Green Sturgeon

The effects on Green Sturgeon were analyzed by comparing changes in water temperature and the frequency of temperature threshold exceedance between Alternative 3 and the No Action Alternative. In addition, potential effects on Green Sturgeon during the Delta portion of their life cycle were evaluated based on changes in Delta outflow. The effects are described and summarized below.

Changes in Water Temperature

Changes in water temperature could affect Green Sturgeon in the Sacramento and Feather rivers. The following describes temperature conditions in those water bodies.

Sacramento River

Average monthly water temperature in the Sacramento River at Keswick Dam under Alternative 3 relative to the No Action Alternative generally would be similar (less than 0.5°F differences) water temperatures under the No Action Alternative during most months of the year (Appendix 6B, Table B-5-2). In September, average water temperatures in wetter years could be increased by up to 0.8°F and decreased by up to 1.2°F in critical years. A similar temperature pattern generally would be exhibited downstream at Ball’s Ferry, Jelly’s Ferry, Bend Bridge, and Red Bluff, with average monthly temperatures progressively increasing in the downstream direction (e.g., average difference of about 3°F between Keswick Dam and Red Bluff). The temperature differences between Alternative 3 and the No Action Alternative in September of wetter years would increase to as high as 3.0°F warmer under Alternative 3 at Red Bluff, while the differences in water temperatures in September associated with Alternative 3 during drier years would remain similar to upstream locations.

Overall, the temperature differences between Alternative 3 and the No Action Alternative would be relatively minor (less than 0.5°F). The similar water temperatures during most months suggest that temperature-related effects on

Green Sturgeon would likely be similar under Alternative 3 and the No Action Alternative.

Feather River

Average monthly water temperatures in the Feather River at the low flow channel under the Alternative 3 relative generally would be similar (within 0.5°F) to water temperatures under the No Action Alternative except in November and December (differences as much as 1.6°F in December in below normal water years) (Appendix 6B, Table B-20-2). In September average monthly water temperatures under Alternative 3 could be somewhat higher (up to about 1.5°F) in wetter years than under the No Action Alternative. Although temperatures in the river would become progressively higher in the downstream direction, the differences between Alternative 3 and the No Action Alternative would exhibit a similar pattern at the downstream locations (Robinson Riffle and Gridley Bridge), with temperatures under Alternative 3 and the No Action Alternative generally becoming more similar at the confluence with the Sacramento River, except in September when the water temperature under Alternative 3 could be up to 4.4 °F higher than under the No Action Alternative and in June when temperatures under Alternative 3 could be up to 0.8°F cooler in drier years.

Overall, the temperature differences between Alternative 3 and the No Action Alternative would be relatively minor (less than 0.5°F). The similar water temperatures during most months suggest that temperature-related effects on Green Sturgeon would likely be similar under Alternative 3 and the No Action Alternative. The somewhat higher water temperatures in September under Alternative 3 could affect spawning by Green Sturgeon in the Feather River.

Changes in Exceedances of Water Temperature Thresholds

Changes in water temperature could result in the exceedance of established water temperature thresholds for Green Sturgeon in the Sacramento and Feather rivers. The following describes the extent of those exceedance for each of those rivers.

Sacramento River

Average monthly water temperatures in the Sacramento River at Bend Bridge under both Alternative 3 and the No Action Alternative would exceed the water temperature threshold of 63°F established for Green Sturgeon larval rearing in August and September, with exceedances under Alternative 3 occurring about 6 percent of the time in August relative the No Action Alternative (7 percent), and about 9 percent of the time in September relative to 12 percent under the No Action Alternative. Average monthly water temperatures at Bend Bridge could be as high as about 73°F during this period. Temperature conditions in the Sacramento River under Alternative 3 could be less likely to affect Green Sturgeon rearing than under the No Action Alternative because of the reduced frequency of exceedance of the 63°F threshold in August and September.

Feather River

Average monthly water temperatures in the Feather River at Gridley Bridge under both Alternative 3 and the No Action Alternative would exceed the water temperature threshold of 64°F established for Green Sturgeon spawning, incubation, and rearing in May, June, and September; no exceedances under either condition would occur in July and August. The frequency of exceedances would be high, with both Alternative 3 and the No Action Alternative exceeding the threshold in June nearly 100 percent of the time. The magnitude of the exceedance also would be substantial, with average monthly temperatures higher than 72°F in June, and higher than 75°F in July and August. Water temperatures under Alternative 3 would exceed the threshold for May about 7 percent less frequently than the No Action Alternative and about 33 percent more frequently in September. Temperature conditions in the Feather River under Alternative 3 could be less likely to result in adverse effects on Green Sturgeon rearing than under the No Action Alternative because of the reduced frequency of exceedance of the 64°F threshold in May. The increase in exceedance frequency in September under Alternative 3 may have little effect on rearing Green Sturgeon as many juvenile sturgeon may have migrated downstream to the lower Sacramento River and Delta by this time.

Changes in Delta Outflow

As described in Appendix 9P, mean (March to July) Delta outflow was used an indicator of potential year class strength and the likelihood of producing a strong year class of sturgeon. The median value over the 82-year CalSim II modeling period of mean (March to July) Delta outflow was predicted to be 9 percent lower under the Alternative 3 than under the No Action Alternative. In addition, the likelihood of mean (March to July) Delta outflow exceeding the threshold of 50,000 cfs was the same under both alternatives.

Summary of Effects on Green Sturgeon

The analysis of the effects of Alternative 3 and the No Action Alternative for Green Sturgeon relied on water temperature model output for the Sacramento and Feather rivers at various locations downstream of Shasta Dam and the Thermalito complex. The temperature model outputs for each of these rivers suggest that thermal conditions and effects on Green Sturgeon in the Sacramento and Feather rivers generally would be slightly less adverse under Alternative 3. This conclusion is supported by the water temperature threshold exceedance analysis that indicated that the water temperature thresholds for Green Sturgeon spawning, incubation, and rearing would be exceeded less frequently under Alternative 3 in the Sacramento River. The water temperature threshold for Green Sturgeon spawning, incubation, and rearing would also be exceeded less frequently during some months in the Feather River but would be exceeded substantially more frequently in September under Alternative 3 and could increase the potential for adverse effects on Green Sturgeon in the Sacramento and Feather rivers relative to the No Action Alternative. The analysis based on Delta outflows suggests that Alternative 3 provides lower mean (March to July) outflows which could result in weaker year classes of juvenile Green Sturgeon relative to the No Action

Alternative. In addition, actions under the No Action Alternative intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities could improve the overall salvage survival of green sturgeon. However, early life stage survival in the natal rivers is crucial in development of a strong year class. Therefore, based primarily on the analysis of water temperatures, Alternative 3 could be less likely to result in adverse effects on Green Sturgeon than the No Action Alternative.

White Sturgeon

Changes in water temperature conditions in the Sacramento and Feather rivers would be the same as those described above for Green Sturgeon. Overall, the temperature differences between Alternative 3 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on White Sturgeon in the Sacramento and Feather rivers.

The water temperature threshold established for White Sturgeon spawning and egg incubation in the Sacramento River at Hamilton City is 61°F during March through June. Both Alternative 3 and the No Action Alternative would exceed this threshold in May and June. The average monthly water temperatures in May under Alternative 3 would exceed this threshold about 49 percent of the time (about 6 percent less frequently than the No Action Alternative). In June, the temperature under Alternative 3 would exceed the threshold about 74 percent of the time (about 13 percent less frequently than the No Action Alternative). Average monthly water temperatures during May and June under Alternative 3 would as high as about 65°F, which is below the 68°F threshold considered lethal for White Sturgeon eggs. Temperature conditions in the Sacramento River under Alternative 3 could be less likely to result in adverse effects on White Sturgeon rearing than under the No Action Alternative because of the reduced frequency of exceedance of the 61°F threshold in May and June.

The analysis of the effects of Alternative 3 and the No Action Alternative for White Sturgeon relied on water temperature model output for the Sacramento River at various locations downstream of Shasta Dam. The temperature model outputs suggest that thermal conditions and effects on White Sturgeon in the Sacramento River generally would be less adverse under Alternative 3. This conclusion is supported by the water temperature threshold exceedance analysis that indicated that the water temperature thresholds for White Sturgeon spawning, incubation, and rearing would be exceeded less frequently under Alternative 3 in the Sacramento River. The reduced frequency of exceedance of water temperature thresholds under Alternative 3 could reduce the potential for adverse effects on White Sturgeon in the Sacramento River relative to the No Action Alternative.

Changes in Delta outflows would be the same as those described above for Green Sturgeon. Mean (March to July) Delta outflow was predicted to be 9 percent lower under Alternative 3 than under the No Action Alternative. In addition, the likelihood of mean (March to July) Delta outflow exceeding the threshold of 50,000 cfs was the same under both alternatives.

Overall, the temperature model outputs suggest that thermal conditions and effects on White Sturgeon in the Sacramento River generally would be slightly less adverse under Alternative 3. The analysis based on Delta outflows suggests that Alternative 3 provides lower mean (March to July) outflows which could result in weaker year classes of juvenile Green Sturgeon relative to the No Action Alternative. However, early life stage survival in the natal rivers is crucial in development of a strong year class. Therefore, based primarily on the analysis of water temperatures, Alternative 3 could be less likely to result in adverse effects on White Sturgeon than the No Action Alternative.

Delta Smelt

As described in Appendix 9G, a proportional entrainment regression model (based on Kimmerer 2008, 2011) was used to simulate adult Delta Smelt entrainment, as influenced by OMR flow in December through March. Results indicate that the percentage of entrainment of migrating and spawning adult Delta Smelt under Alternative 3 would be 7.3 to 8.5 percent, depending on the water year type, with a long term average percent entrainment of 7.9 percent. Percent entrainment of adult Delta Smelt under Alternative 3 would be similar to results under the No Action Alternative.

As described in Appendix 9G, a proportional entrainment regression model (based on Kimmerer 2008) was used to simulate larval and early juvenile Delta Smelt entrainment, as influenced by OMR flow and location of X2 in March through June. Results indicate that the percentage of entrainment of larval and early juvenile Delta Smelt under Alternative 3 would be 5.6 to 20.5 percent, depending on the water year type, with a long term average percent entrainment of 12.7 percent, and highest entrainment under Critical water year conditions. Percent entrainment of larval and early juvenile Delta Smelt under Alternative 3 would be similar to results under the No Action Alternative, except in above- and below-normal years when entrainment would be higher under Alternative 3 by 5 to 6 percent.

The average September through December X2 position in km was used to evaluate the fall abiotic habitat availability for Delta Smelt under the Alternatives. X2 values simulated in the CalSim II model for each alternative were averaged over September through December, and compared. Results indicate that under the No Action Alternative, the X2 position would range from 75.9 km to 92.4 km, depending on the water year type, with a long term average X2 position of 84 km. The most eastward location of X2 is predicted under Critical water year conditions. The X2 positions predicted under Alternative 3 would be similar to results under the No Action Alternative in drier water year types. In wetter years, the X2 location would be further east under Alternative 3 than under the No Action Alternative, by 6.0 to 9.7 km. This difference is largely due to implementation of 2008 USFWS BO RPA Component 3 (Action 4), under the No Action Alternative, which requires Reclamation and DWR to provide sufficient Delta outflow to maintain a monthly average X2 no more eastward than 74 km in Above Normal and Wet years. Under Alternative 3, the long term average X2 position would be 88.1 km, a location that does not provide for the advantageous overlap of the low salinity zone with Suisun Bay/Marsh.

Overall, Alternative 3 likely would have adverse effects on Delta Smelt, as compared to the No Action Alternative, primarily due to increased percentage entrainment during larval and juvenile life stages, and less favorable location of Fall X2 in wetter years, and on average. Given the current condition of the Delta Smelt population, even small differences between alternatives may be important.

Longfin Smelt

The effects of the Alternative 3 as compared to the No Action Alternative were analyzed based on the direction and magnitude of OMR flows during the period (December through June) when adult, larvae, and young juvenile Longfin Smelt are present in the Delta in the vicinity of the export facilities (Appendix 5A). The analysis was augmented with calculated Longfin Smelt abundance index values (Appendix 9G) per Kimmerer et al. (2009), which is based on the assumptions that lower X2 values reflect higher flows and that transporting Longfin Smelt farther downstream leads to greater Longfin Smelt survival. The index value indicates the relative abundance of Longfin Smelt and not the calculated population.

As described in Appendix 5A, OMR flows would generally be negative in all months, except April and May where OMR flows would be positive, under the No Action Alternative and the long-term average negative flow ranges from -2,700 to -6,200 cfs from December through June. Because there would be no restrictions on export pumping from December 1 to June 15 due to OMR flow criteria under Alternative 3, OMR flows would generally be more negative during this time period under Alternative 3 as compared to the No Action Alternative. The greatest differences between alternatives would be in April and May, where long-term average OMR flows would be negative under Alternative 3 instead of positive as under the No Action Alternative. The increase in the magnitude of negative flows, particularly the negative flows in April and May, under Alternative 3 as compared to the No Action Alternative could increase the potential for entrainment of Longfin Smelt at the export facilities.

Under Alternative 3, Longfin Smelt abundance index values range from 1,147 under critical water year conditions to a high of 16,635 under wet water year conditions, with a long-term average value of 7951 (Appendix 9G). Under the No Action Alternative, Longfin Smelt abundance index values range from 947 under critical water year conditions to a high of 15,822 under wet water year conditions, with a long-term average value of 7,257.

Results indicate that the Longfin Smelt abundance index values would be lower in every water year type under Alternative 3 than under the No Action Alternative, with a long-term average index for Alternative 3 that is 7.6 percent lower than the long-term average index under the No Action Alternative. The greatest decrease in the Longfin Smelt abundance index occurs in above normal years where the index value is 12.3 percent less under Alternative 3 than under the No Action Alternative. For below normal, dry, and critical water years, the Longfin Smelt abundance index values would be 4.6 to 9.9 percent lower under Alternative 3 than under the No Action Alternative.

Overall, based on the increase in frequency and magnitude of negative OMR flows and the lower Longfin Smelt abundance index values, potential adverse effects on the Longfin Smelt population under Alternative 3 likely would be greater than under the No Action Alternative. Given the current condition of the Longfin Smelt population, even small differences between alternatives may be important.

Sacramento Splittail

Under Alternative 3, flows entering the Yolo Bypass generally would be somewhat higher than under the No Action Alternative from December through March, especially during wetter years (Appendix 5A, Table C-26-2), providing similar value to Sacramento Splittail because of the similar area of potential habitat (inundation). Given the relatively minor changes in flows into the Yolo Bypass, and the inherent uncertainty associated with the resolution of the CalSim II model (average monthly outputs), it is concluded that there would be no definitive difference in effects on Sacramento Splittail between Alternative 3 and the No Action Alternative.

Reservoir Fishes

The analysis of effects associated with changes in operation on reservoir fishes relied on evaluation of changes in available habitat (reservoir storage) and anticipated changes in black bass nesting success.

Changes in CVP and SWP water supplies and operations under Alternative 3 as compared to the No Action Alternative generally would result in higher reservoir storage in CVP and SWP reservoirs in the Central Valley Region. Storage levels in Shasta Lake, Lake Oroville, and Folsom Lake would be higher under Alternative 3 as compared to the No Action Alternative (Appendix 9F).

The greatest increases in Shasta Lake storage could be as high as 15 percent. Storage in Lake Oroville could be increased by up to 30 percent in some months under Alternative 3 as compared to the No Action Alternative. Storage in Folsom Lake could be increased up to around 20 percent in some months of some water year types and could be reduced by up to 10 percent in July, August, and September. Additional information related to monthly reservoir elevations is provided in Appendix 5A, CalSim II and DSM2 Modeling. Although aquatic habitat within the CVP and SWP water supply reservoirs is not limiting, storage volume, as an indicator of how much habitat is available to fish species inhabiting these reservoirs, suggests that the amount of habitat for reservoir fishes could be higher under Alternative 3 as compared to the No Action Alternative.

Results of the bass nesting success analysis are presented in Appendix 9F, Reservoir Fish Analysis Documentation. Black bass nest survival in CVP and SWP reservoirs is anticipated to be near 100 percent in March and April due to increasing reservoir elevations. For May, the likelihood of nest survival for Largemouth and Smallmouth Bass in Shasta Lake being in the 40 to 100 percent range is similar under Alternative 3 and the No Action Alternative. For June, the likelihood of nest survival being greater than 40 percent for Largemouth and Smallmouth Bass is the same under Alternative 3 and the No Action Alternative; however, nest survival of greater than 40 percent is likely only in about 20 percent of the years evaluated. For Spotted Bass, the likelihood of nest survival being greater than 40 percent is high (nearly 100 percent) in May under both Alternative 3 and the No Action Alternative. For June, Spotted Bass nest survival would be less than for May due to greater daily reductions in water surface elevation as Shasta Lake is drawn down. The likelihood of survival being greater than 40 percent is about 10 percent less under Alternative 3 as compared to the No Action Alternative.

For May and June, the likelihood of nest survival for Largemouth Bass in Lake Oroville being in the 40 to 100 percent range is somewhat (4 to 10 percent) lower under Alternative 3 as compared to the No Action Alternative. However, June nest survival of greater than 40 percent is likely only in about 30 percent of the years evaluated under Alternative 3. The likelihood of nest survival for Smallmouth Bass in Lake Oroville exhibits nearly the same pattern. For Spotted Bass, the likelihood of nest survival being greater than 40 percent is high (over 90 percent) in May under both Alternative 3 and the No Action Alternative with the likelihood of greater than 40 percent survival being similar under Alternative 3 as compared to the No Action Alternative. For June, Spotted Bass survival would be less than for May due to greater daily reductions in water surface elevation as Lake Oroville is drawn down. The likelihood of survival being greater than 40 percent is substantially lower (nearly 20 percent) under Alternative 3 as compared to the No Action Alternative.

Black bass nest survival in Folsom Lake is anticipated to be near 100 percent in March, April, and May due to increasing reservoir elevations. For June, the likelihood of nest survival for Largemouth Bass and Smallmouth Bass in Folsom Lake being in the 40 to 100 percent range would be about 5 percent lower under Alternative 3 than the No Action Alternative. For Spotted Bass, nest survival for June would be less than for May due to greater daily reductions in water surface elevation. However, the likelihood of survival being greater than 40 percent is around 7 percent lower under Alternative 3 as compared to the No Action Alternative. Most black bass spawning likely occurs prior to June, such that drawdowns during June would likely affect only a small proportion of the spawning population. Thus, it is concluded that effects on black bass nesting success would be similar under Alternative 3 and the No Action Alternative.

Summary of Effects on Reservoir Fishes

The analysis of the effects of Alternative 3 and the No Action Alternative for reservoir fish relied on CalSim II output for reservoir storage levels and water surface elevation changes as described in Appendix 9F. As described above, reservoir storage is anticipated to be increased under Alternative 3 relative to the No Action Alternative and this increase could affect the amount of warm and cold water habitat available within the reservoirs. However, it is unlikely that aquatic habitat within the CVP and SWP water supply reservoirs is limiting.

The analysis of black bass nest survival based on changes in water surface elevation during the spawning period indicated that the likelihood of high (>40 percent) nest survival in most of the reservoirs would be similar in March, April, and May under Alternative 3 and the No Action Alternative, but somewhat lower in June. Most black bass spawning likely occurs prior to June, such that drawdowns during June would likely affect only a small proportion of the spawning population. Overall, the results of the habitat and nest survival analysis suggest that conditions in the reservoirs likely to support self-sustaining populations of black bass would be similar under Alternative 3 and the No Action Alternative.

Other Species

Several other fish species could be affected by changes in operations that influence temperature and flow. The following describes the extent of these changes and the potential effects on these species.

Pacific Lamprey

Little information is available on factors that influence populations of Pacific Lamprey in the Sacramento River, but they are likely affected by many of the same factors as salmon and steelhead because of the parallels in their life cycles.

Pacific Lamprey would be subjected to the same temperature conditions described above for salmonids. Average monthly water temperatures under Alternative 3 and the No Action Alternative would generally be similar. Pacific Lamprey can tolerate higher temperatures than salmonids, up to around 72°F during their entire life history. Given the somewhat increased flows and similar temperatures under Alternative 3 and the No Action Alternative from January through the summer, there would be little difference in potential effects on Pacific Lamprey in the Sacramento, Feather, and American rivers under Alternative 3 and the No Action Alternative. This conclusion likely applies to other species of lamprey that inhabit these rivers (e.g., River Lamprey).

Striped Bass, American Shad, and Hardhead

Average monthly water temperatures under Alternative 3 and the No Action Alternative would generally be similar. Striped Bass, American Shad, and Hardhead can generally tolerate higher temperatures than salmonids. Based on the similar water temperatures during their spawning and incubation period under Alternative 3, it is likely that thermal conditions for and effects on Striped Bass, American Shad, and Hardhead in the Sacramento, Feather, and American rivers would be similar under Alternative 1 and the No Action Alternative.

Alternative 3 would result in a more eastward X2 position as compared to the No Action Alternative during April and May, with similar values in June (Appendix 5A, Section C Table C-16-2). Based on Kimmerer (2002) and Kimmerer et al. (2009), this change in X2 would likely reduce the survival index and the habitat index as measured by salinity for Striped Bass and abundance and habitat index for American Shad. In addition, the increased bag limits and ability of anglers to retain Striped Bass that are 12 inches in length versus 18 inches under Alternative 3 could reduce the ability to meet the doubling goals for Striped Bass populations under the requirements of Section 3406(b)(1) of CVPIA.

Overall, Alternative 3 likely would have similar effects on Hardhead, but slightly greater potential for adverse effects on Striped Bass and American Shad as compared to the No Action Alternative, primarily due to the potential for reduced survival during larval and juvenile life stages, and less favorable location of Spring X2 on average.

Stanislaus River/Lower San Joaquin River

Fall-Run Chinook Salmon

Changes in operations influence temperature and flow conditions that could affect fall-run Chinook Salmon in the Stanislaus River downstream of Goodwin Dam and in the San Joaquin River below Vernalis. The following describes those changes and their potential effects.

Changes in Water Temperature (Stanislaus River)

Average monthly water temperatures in the Stanislaus River at Goodwin Dam under Alternative 3 and the No Action Alternative generally would be similar (differences less than 0.5°F), except from May through October of drier years when average monthly water temperatures could be up to 2.9°F cooler (September) under Alternative 3 as compared to the No Action Alternative (Appendix 6B, Table B-17-2).

Downstream at Orange Blossom Bridge, average monthly water temperatures would be similar (less than 0.5°F differences) under Alternative 3 and the No Action Alternative, except in October when water temperatures under Alternative 3 could be higher than water temperatures under the No Action Alternative by up to 1.5°F in some water year types. Water temperatures in June under Alternative 3 would be substantially higher (2.3°F on average) and up to 3.7°F warmer in wetter years. In September of drier years, water temperatures under Alternative 3 could be cooler (by up to 2.1°F in critical years) than under the No Action Alternative (Appendix 6B, Table B-18-2).

This temperature pattern would continue downstream to the confluence with the San Joaquin River, although temperatures and magnitude of temperature differences under Alternative 3 compared to the No Action Alternative would progressively increase in a downstream direction except for in September when temperature differences would diminish at this location (Appendix 6B, Table B-19-2).

Overall, the temperature differences between Alternative 3 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on fall-run Chinook Salmon in the Stanislaus River. Based on the life history timing for fall-run Chinook Salmon, the lower water temperatures in September and October below Goodwin Dam under Alternative 3 likely would have little effect on fall-run Chinook Salmon spawning as the majority of spawning occurs later, in November. The higher water temperatures in June at Orange Blossom Bridge and the mouth under Alternative 3 may increase the likelihood of adverse effects on fall-run Chinook Salmon rearing in the Stanislaus River, if they are present, as compared to the No action Alternative.

Changes in Exceedance of Water Temperature Thresholds (Stanislaus River)

While specific water temperature thresholds for fall-run Chinook Salmon in the Stanislaus River are not established, temperatures generally suitable for fall-run Chinook Salmon spawning (56°F) would be exceeded in October (over 30 percent of the time) and November over 20 percent of the time in the Stanislaus River at Goodwin Dam under Alternative 3 (Appendix 6B, Table B-17-2). Similar exceedances would occur under the No Action Alternative, although average monthly water temperatures under Alternative 3 would remain lower than under the No Action Alternative during the periods when the threshold is exceeded. Water temperatures under Alternative 3 also would exceed the threshold about 5 percent less frequently in November than under the No Action Alternative. Water temperatures for rearing generally would be below 56°F, except in May and June when average monthly water temperatures would reach about 60°F under the No Action Alternative (Appendix 6B, Figures B-17-8 and B-17-9).

Downstream at Orange Blossom Bridge, water temperatures suitable for fall-run Chinook Salmon spawning would be exceeded frequently under both Alternative 3 and the No Action Alternative during October and November. Under Alternative 3, average monthly water temperatures would exceed 56°F about 87 percent of the time in October. This would be about 31 percent more frequently than under the No Action Alternative. In November, average monthly water temperatures would exceed 56°F about 24 percent of the time under Alternative 3, which would be about 9 percent less frequent than under the No Action Alternative (Appendix 6B, Figure B-18-1 and B-18-2).

During January through May, rearing fall-run Chinook Salmon under Alternative 3 would occasionally encounter average monthly water temperatures that exceed 56°F at Orange Blossom Bridge under both Alternative 3 and the No Action Alternative (Appendix 6B, Table B-18-2).

Changes in Egg Mortality (Stanislaus River)

For fall-run Chinook Salmon in the Stanislaus River, the long-term average egg mortality rate is predicted to be around 6 percent, with higher mortality rates (in excess of 13 percent) occurring in critical dry years under Alternative 3. Overall, egg mortality would be similar under Alternative 3 and the No Action Alternative in all water year types (Appendix 9C, Table B-1).

Changes in Delta Hydrodynamics

San Joaquin River-origin Chinook Salmon smolts are most abundant in the Delta from April through June. Near the confluence of the San Joaquin River and the Mokelumne River, the median proportion of positive velocities would be slightly lower under Alternative 3 relative to the No Action Alternative in April and May, and similar in June (Appendix 9K). On Old River downstream of the facilities, the median proportion of positive velocities would be substantially lower in April and May under Alternative 3 relative to the No Action Alternative, but would be only moderately lower in June. In Old River upstream of the facilities, the median proportion of positive velocities would be similar for Alternative 3 relative to the No Action Alternative in June. In April and May, values for Alternative 3 would be slightly higher under Alternative 3 relative to the No Action Alternative. On the San Joaquin River downstream of the Head of Old River, the median proportion of positive velocities would be similar under Alternative 3 relative to the No action Alternative in April, May and June.

Changes in Junction Entrainment

At the Head of Old River junction, entrainment under Alternative 3 would be slightly higher in April, May, and June (Appendix 9L). Median entrainment into Turner Cut would be slightly greater under Alternative 3 during April and May, and similar in June. At the Columbia Cut junction, entrainment would be moderately higher under Alternative 3 during April and May, whereas entrainment would be slightly higher in June. Entrainment probabilities at the Middle River junction from April through June would be moderately greater under Alternative 3 relative to the No action Alternative. A similar pattern would be observed at the Old River junction.

Changes in Juvenile Salmonid Passage through the Delta (Trap and Haul)

Poor survival of juvenile salmonids in the Sacramento-San Joaquin Delta has been hypothesized as a major contributor to declines in the number of returning adults and may be a significant impediment to the recovery of threatened or endangered populations (NOAA 2009). Under Alternative 3, fish would be trapped in the San Joaquin River between the mouth of the Stanislaus River and the Head of Old River to capture juveniles migrating from natal rearing habitat in the San Joaquin River, Merced River, Tuolumne River and Stanislaus River. Captured fish would be transported by barge through the Delta and released at locations within San Francisco Bay. Although trucks are currently used to transport hatchery reared salmonids and salvaged fishes (including salmonids), barging results in greater survival benefits (Ward et al. 1997) and may reduce straying of returning adults.

In response to low survival in the Columbia River hydro system, a transportation program was initiated where migrating salmonids (Chinook salmon and steelhead) are captured at dams and transported by barge to the lowest dam in the system before being released (Williams et al. 2004). The effectiveness of the Columbia River transportation program has been questioned because although survival of transported Chinook (≈98 percent; McMichael et al. 2011) is greater than in-river migrants (≈50 percent; Faulkner et al. 2010), SAR rates have not been proportional to the increase in hydro system survival. The most recent evidence suggests that that differences in ocean entry timing that occur due to the rapid rate of barge transport and the long distances transported are likely responsible for the lower post-hydro system survival of transported fish (Muir et al 2006; Rechisky et al 2012). To assess the potential benefits and risks of a transportation program for salmonids in the San Joaquin River, an analysis of CWT recovery rates for Chinook Salmon reared at the Feather River Hatchery and the Mokelumne River Hatchery was performed (Appendix 9O). Based on this analysis, Alternative 3 is expected to improve the survival of juvenile fall-run Chinook Salmon and steelhead smolts originating from the San Joaquin River basin in comparison to the No Action Alternative. Previous work on the Columbia River suggests that benefits may be greater than demonstrated in Appendix 9O if juveniles were transported by barge instead of truck (Ward et al. 1997). The program would also improve the survival of spring-run Chinook Salmon if these fish become established as part of the San Joaquin River Restoration Program, or as part of the New Melones fish passage project. As indicated in Chapter 3, Description of Alternatives, this action will include measures to quantify the benefit.

While a trap and haul program may increase survival, it also may result in unintended consequences or population impacts. For example, a study of returning adult Chinook Salmon and steelhead on the Columbia River following transport as juveniles found that the proportion of adults successfully homing was significantly lower and that the unaccounted loss and permanent straying into non-natal rivers was higher for barged fish of both species (Keefer et al. 2008). Increased straying could have consequences for populations in their natal streams, but also could adversely influence populations in other streams if those fish breed with other wild populations. The conditions and transport distances in the Delta differ from those studied on the Columbia River system, thus the overall influence on straying is uncertain.

However, as indicated in Appendix 9O, straying rates of transported fish are anticipated to be greater than fish allowed to migrate within the river system. An important consideration for this analysis of straying is that all releases into the bay were transported by truck to bypass the Delta. Barge transport where water is recirculated may reduce straying by allowing fish to “sample” water along the migration route. Additionally, the location of collection on the San Joaquin River would be downstream of natal rearing locations allowing fish to experience portions of the migration route during rearing. In addition, trapping and hauling is inconsistent with CDFW’s goal of achieving volitional fish passage.

Summary of Effects on Fall-Run Chinook Salmon

The analysis of temperatures indicates lower temperatures and a lesser likelihood of exceedance of suitable temperatures for spawning and rearing of fall-run Chinook Salmon under Alternative 3 as compared to the No Action Alternative in the Stanislaus River downstream of Goodwin Dam and in the San Joaquin River at Vernalis. The effect of lower temperatures is not reflected in the overall mortality of fall-run Chinook Salmon eggs predicted by Reclamation’s salmon mortality model for fall-run in the Stanislaus River.

Implementation of a fish passage project under the No Action Alternative, although intended to address the limited availability of suitable habitat for spring-run Chinook Salmon and steelhead in the Stanislaus River reaches downstream of Goodwin Dam, likely would provide some benefit to fall-run Chinook Salmon if passage for fall-run Chinook Salmon was provided and additional habitat could be accessed. Any potential benefit to fall-run Chinook Salmon under the No Action

Alternative relative to Alternative 3 is uncertain. The potential benefits of actions under the No Action Alternative intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities could improve the overall salvage survival of fall-run Chinook Salmon relative to Alternative 3.

Overall, Alternative 3 likely would have similar effects on the fall-run Chinook Salmon population in the San Joaquin River watershed as compared to the No Action Alternative. Alternative 3 could also provide beneficial effects to juvenile fall-run Chinook Salmon as a result of trap and haul passage through the Delta and ocean harvest restrictions. It remains uncertain, however, if predator management actions under Alternative 3 and fish passage under the No Action Alternative would benefit fall-run Chinook Salmon.

Steelhead

Changes in operations that influence temperature and flow conditions in the Stanislaus River downstream of Goodwin Dam and the San Joaquin River downstream of the Stanislaus River confluence, as measured at Vernalis could affect steelhead. The following describes those changes and their potential effects.

Changes in Water Temperature (Stanislaus River)

Average monthly water temperatures in the Stanislaus River at Goodwin Dam under Alternative 3 and the No Action Alternative generally would be similar (differences less than 0.5°F), except from May through October of drier years when average monthly water temperatures could be up to 2.9°F cooler (September) under Alternative 3than under the No Action Alternative.

Downstream at Orange Blossom Bridge, average monthly water temperatures would be similar (less than 0.5°F differences) under Alternative 3 and the No Action Alternative, except in October when water temperatures under Alternative 3 could be higher than water temperatures under the No Action Alternative by up to 1.5°F in some water year types. Water temperatures in June under Alternative 3 would be substantially higher (2.3°F on average) and up to 3.7°F warmer in wetter years. In September of drier years, water temperatures under Alternative 3 could be cooler (by up to 2.1°F in critical years) than under the No Action Alternative.

This temperature pattern would continue downstream to the confluence with the San Joaquin River, although temperatures and magnitude of temperature differences under Alternative 3 compared to the No Action Alternative would progressively increase in a downstream direction except for in September when temperature differences would diminish at this location (Appendix 6B, Table B-19-2).

Overall, the temperature differences between Alternative 3 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on steelhead in the Stanislaus River. The higher water temperatures in June at Orange Blossom Bridge and the mouth under Alternative 3 may increase the likelihood of adverse effects on steelhead rearing in the Stanislaus River as compared to the No action Alternative. The lower water temperatures in September of drier years under Alternative 3 may decrease the likelihood of adverse effects to steelhead rearing in the Stanislaus River during this month.

Changes in Exceedance of Water Temperature Thresholds (Stanislaus River)

Average monthly water temperatures in the Stanislaus River at Orange Blossom Bridge would frequently exceed the temperature threshold (56°F) established for adult steelhead migration under both Alternative 3 and the No Action Alternative during October and November. Under Alternative 3, average monthly water temperatures would exceed 56°F about 87 percent of the time in October and about 57 percent of the time under the No Action Alternative. In November, average monthly water temperatures would exceed 56°F about 24 percent of the time under Alternative 3, which would be about 9 percent less frequent than under the No Action Alternative.

From January through May, the temperature threshold at Orange Blossom Bridge is 55°F, which is intended to support steelhead spawning. This threshold could be exceeded about 1 percent of the time under Alternative 3 in February. In March through May, exceedances would occur under both alternatives in each month, with the threshold most frequently exceeded (nearly half the time) in May. Compared to the No Action Alternative, water temperatures under Alternative 3 would exceed the threshold 3 percent more frequently in March, 1 percent more frequently in April, and 4 percent more frequently in May. From June through November, the temperature threshold of 65°F established to support steelhead rearing would be exceeded by both Alternative 3 and No Action Alternative in all months but November, with the highest frequency of exceedance in July (19 percent under Alternative 3). The differences between Alternative 3 and No Action Alternative, however, would be variable depending on the month, with Alternative 3 exceeding the threshold up to about 6 percent less frequently than under the No Action Alternative in June and from August through October. Under Alternative 3, water temperatures would exceed the rearing temperature threshold up to 4 percent more frequently in April, May, and July.

Average monthly water temperatures also would exceed the threshold (52°F) established for smoltification at Knights Ferry. At Goodwin Dam, about 4 miles upstream of Knights Ferry, average monthly water temperatures under Alternative 3 would exceed 52°F in March, April, and May about 12 percent, 30 percent, and 63 percent of the time, respectively and 2 percent of the time in January and February. By comparison to the No Action Alternative, Alternative 3 would result in exceedances occurring about 2 to 4 percent more frequently during the January through March period. Farther downstream at Orange Blossom Bridge, the temperature threshold for smoltification is higher (57°F) and would be exceeded less frequently. The magnitude of the exceedance also would be less. Average monthly water temperatures under Alternative 3 and the No Action Alternative would not exceed the threshold during January through March. In April and May, exceedances of 3 percent and 17 percent would occur under

Alternative 3, which would be nearly the same as under the No Action Alternative.

Overall, the differences in exceedance frequency between Alternative 3 and the No Action Alternative would be relatively small, with the exception of substantial differences in the frequency of exceedances in October when the average monthly water temperatures under Alternative 3 would exceed the threshold for adult steelhead migration about 28 percent less frequently and in April during the spawning period when the frequency would be about 17 percent less. Given the frequency of exceedance under both Alternative 3 and the No Action Alternative and the generally stressful temperature conditions in the river, the substantial differences (improvements) in October and April under Alternative 3 suggest that there would be less potential to result in adverse effects on steelhead under Alternative 3 than under the No Action Alternative. Even during months when the differences would be relatively small, the lower frequency of exceedances under Alternative 3 suggest that there would be less potential to result in adverse effects on steelhead under Alternative 3 than under the No Action Alternative.

Changes in Delta Hydrodynamics

San Joaquin River-origin steelhead generally move through the Delta during spring; however, there is less information on their timing relative to Chinook Salmon. Thus, hydrodynamics in the entire January through June period have the potential to affect juvenile steelhead. For a description of potential hydrodynamic effects on steelhead, see the descriptions for winter-run Chinook Salmon in the Sacramento Basin and fall-run Chinook Salmon in the San Joaquin River basin above.

Summary of Effects on Steelhead

Given the frequency of exceedance under both Alternative 3 and the No Action Alternative, water temperature conditions for steelhead in the Stanislaus River would be generally stressful in the fall, late spring, and summer months. The differences in temperature exceedance (both positive and negative) between Alternative 3 and the No Action Alternative would be relatively small, with no clear benefit associated with either alternative. However, because Alternative 3 generally would exceed thresholds less frequently during the warmest months, it may have slightly less impact than the No Action Alternative. Alternative 3 also could provide additional beneficial effects to juvenile steelhead as a result of trap and haul passage through the Delta. It remains uncertain, however, if predator management actions under Alternative 3 would benefit steelhead.

Implementation of the fish passage program under the No Action Alternative intended to address the limited availability of suitable habitat for steelhead in the Stanislaus River reaches downstream of Goodwin Dam could provide a benefit to Central Valley steelhead in the Stanislaus River. This is particularly important in light of anticipated increases in water temperature associated with climate change in 2030. In addition, RPA actions intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities could improve the overall salvage survival of steelhead under the No Action Alternative. Thus, it is concluded that the potential for adverse effects on steelhead under Alternative 3 would be greater, principally because Alternative 3 does not include a strategy to address water temperatures critical to steelhead sustainability over the long term with climate change by 2030.

White Sturgeon

Evidence of White Sturgeon spawning has been recorded in the San Joaquin River upstream of the confluence with the Stanislaus River. While flows in the San Joaquin River upstream of the Stanislaus River are expected be similar under all alternatives, flow contributions from the Stanislaus River could influence water temperatures in the San Joaquin River where White Sturgeon eggs or larvae may occur during the spring and early summer. The magnitude of influence on water temperature would depend on the proportional flow contribution of the Stanislaus River and the temperatures in both the Stanislaus and San Joaquin rivers. The potential for an effect on White Sturgeon eggs and larvae would be influenced by the proportion of the population occurring in the San Joaquin River. In consideration of this uncertainty, it is not possible to distinguish potential effects on White Sturgeon between alternatives.

Reservoir Fishes

The analysis of effects associated with changes in operation on reservoir fishes relied on evaluation of changes in available habitat (reservoir storage) and anticipated changes in black bass nesting success.

Under Alternative 3, storage in New Melones could be increased up to around 20 percent in some months of some water year types (Appendix 5A). Additional information related to monthly reservoir elevations is provided in Appendix 5A, CalSim II and DSM2 Modeling. It is anticipated that aquatic habitat within New Melones is not limiting; however, storage volume is an indicator of how much habitat is available to fish species inhabiting these reservoirs. Therefore, the amount of habitat for reservoir fishes could be increased under Alternative 3 as compared to the No Action Alternative.

Results of the bass nesting success analysis are presented in Appendix 9F. For March, the likelihood of Largemouth Bass and Smallmouth Bass nest survival in New Melones being above 40 percent is 100 percent under Alternative 3 and the No Action Alternative. For April, the likelihood that nest survival of Largemouth Bass and Smallmouth Bass is between 40 and 100 percent is reasonably high (around 80 percent) but is substantially (about 10 percent) higher under Alternative 3 than under the No Action Alternative. For May, the pattern is similar with the likelihood of high nest survival being about 6 percent greater under Alternative 3. For June, the likelihood of survival being greater than 40 percent for Largemouth Bass and Smallmouth Bass in New Melones is similar under Alternative 3 and the No Action Alternative. For Spotted Bass, nest survival from March through June is anticipated to be near 100 percent in every year under both Alternative 3 and the No Action Alternative. Most black bass spawning likely occurs prior to June, such that drawdowns during June would likely affect only a small proportion of the spawning population. Thus, it is concluded that effects on black bass nesting success would be similar under Alternative 3 and the No Action Alternative.

Other Species

Changes in operations that influence temperature and flow conditions in the Stanislaus River downstream of Keswick Dam and the San Joaquin River at Vernalis could affect other species such as lampreys, Hardhead, and Striped Bass.

As described above, average monthly water temperatures in the Stanislaus River at Goodwin Dam under Alternative 3 and the No Action Alternative generally would be similar. Downstream at Orange Blossom Bridge, average monthly water temperatures under Alternative 3 generally would be similar to water temperatures under the No Action Alternative except in September when they could be cooler and October when they could be warmer than under the No Action Alternative. This temperature pattern would continue downstream to the confluence with the San Joaquin River, although temperatures would progressively increase. Water temperatures from May to July may also be warmer under Alternative 3 compared to the No Action Alternative (Appendix 6B, Table B-19-2).

In general, lamprey species can tolerate higher temperatures than salmonids, up to around 72°F during their entire life history. Because lamprey ammocoetes remain in the river for several years, any substantial flow reductions or water temperature increases could result in adverse effects on larval lamprey. Given the slightly lower flows and increased water temperatures during portions of their spawning and incubation period, it is likely that the potential to affect lamprey species in the Stanislaus and San Joaquin rivers would be somewhat greater under Alternative 3 and the No Action Alternative.

In general, Striped Bass and Hardhead also can tolerate higher temperatures than salmonids. Thus, thermal conditions for these species are expected to be similar under Alternative 3 and the No Action Alternative. However, implementation of a predator control program under Alternative 3 could result in adverse effects on Striped Bass.

San Francisco Bay Area Region

Killer Whale

As described above for the comparison of Alternative 1 to the No Action Alternative, it is unlikely that the Chinook Salmon prey base of killer whales, supported heavily by hatchery production of fall-run Chinook Salmon, would be appreciably affected by any of the alternatives.

9.4.3.4.2 Alternative 3 Compared to the Second Basis of Comparison

As described in Chapter 3, Description of Alternatives, the CVP and SWP operations and ongoing operational management policies of the CVP and SWP under Alternative 3 would be similar to the operational assumptions under the Second Basis of Comparison except for changes to water demand assumptions, OMR flow criteria, and operations of New Melones Reservoir to meet SWRCB D-1641 flow requirements on the San Joaquin River at Vernalis. As a consequence, conditions for fish and aquatic resources would be relatively unchanged in most of the system under Alternative 3. The following briefly summarizes these minor changes, but focuses on portions of the CVP and SWP where changes would occur under Alternative 3 relative to the Second Basis of Comparison.

Trinity River Region

Coho Salmon

The analysis of effects associated with changes in operation on Coho Salmon was conducted using temperature model outputs for Lewiston Dam to anticipate the likely effects on conditions in the Trinity River downstream of Lewiston Dam for Coho Salmon.

Long-term average monthly water temperature in the Trinity River at Lewiston Dam under Alternative 3 would be similar (less than 0.5°F) to long-term average water temperatures under the Second Basis of Comparison in all months. The greatest differences would occur in critical years when average monthly temperatures would be 0.6°F lower in September and October and 0.8°F higher in November under Alternative 3 (Appendix 6B, Table B-1-5). The differences in the frequency with which Alternative 3 and the Second Basis of Comparison would exceed established temperature thresholds also would be small, with water temperatures under Alternative 3 exceeding thresholds about 0-2 percent less frequently than under the Second Basis of Comparison.

Given the similarity of the results and the inherent uncertainty associated with the resolution of the water temperature model (average monthly outputs), it is concluded that Alternative 3 and the Second Basis of Comparison are likely to have similar effects on the Coho Salmon population in the Trinity River.

Spring-run Chinook Salmon

As described above for Coho Salmon, water temperatures would generally be similar (less than 0.5°F difference) under Alternative 3 and the Second Basis of Comparison. Similarly, the differences in the frequency with which water temperatures under Alternative 3 and the Second Basis of Comparison would exceed established temperature thresholds also would be small, with Alternative 3 exceeding water temperature thresholds about 1 to 2 percent less frequently than the Second Basis of Comparison.

Given the similarity of the results and the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), it is concluded that Alternative 3 and Second Basis of Comparison are likely to have similar effects on the spring-run Chinook Salmon population in the Trinity River.

Fall-Run Chinook Salmon

As described above for Coho Salmon, water temperatures under Alternative 3 and the Second Basis of Comparison generally would be similar (Appendix 6B, Table B-1-5. This is reflected in the egg mortality results, which indicate similar levels of mortality, under Alternative 3 and the Second Basis of Comparison (Appendix 9C, Table 5-5).

Given the similarity of the results and the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), it is concluded that Alternative 3 and Second Basis of Comparison are likely to have similar effects on the fall-run Chinook Salmon population in the Trinity River.

Steelhead

Differences in water temperature conditions for steelhead in the Trinity River between Alternative 3 and the Second Basis of Comparison would be minor as described above for salmon. These results suggest that conditions for steelhead in the Trinity River generally would be similar under Alternative 3 and the Second Basis of Comparison.

Green Sturgeon

Green Sturgeon would be subjected to the same water temperature conditions described above for salmonids. The similarity in temperatures between Alternative 3 and the Second Basis of Comparison suggest that conditions for Green Sturgeon in the Trinity River generally would be similar under Alternative 3 and the Second Basis of Comparison.

Reservoir Fishes

Reservoir fishes in Trinity Lake would be exposed to relatively minor differences in storage under Alternative 3 as compared to the Second Basis of Comparison and these relatively small differences would have little effect on the amount of habitat available for these species. Black bass nesting survival would be similar under Alternative 3 and the Second Basis of Comparison. Overall, effects on reservoir fishes in Trinity Lake would be similar under both Alternative 3 and the Second Basis of Comparison.

Pacific Lamprey and Eulachon

As described above for Coho Salmon, there would be only minor differences in water temperatures between Alternative 3 and the Second Basis of Comparison. This suggests that water temperature conditions for Pacific Lamprey and Eulachon in the Trinity River and Klamath River downstream of the confluence generally would be similar under Alternative 3 and the Second Basis of Comparison.

Sacramento River System

Winter-run Chinook Salmon

Changes in operations that influence temperature and flow conditions in the Sacramento River downstream of Keswick Dam could affect winter-run Chinook Salmon. The following describes those changes and their potential effects.

Changes in Water Temperature

Long-term average monthly water temperature in the Sacramento River at Keswick Dam under Alternative 3 and the Second Basis would be similar (Appendix 6B, Table B-5-5). There would be slight differences in the frequency of exceeding temperature thresholds under Alternative 3 and the Second Basis of Comparison with the frequency of exceedance being up to 4 percent less under Alternative 3 at Balls Ferry and up to 4 percent more at Bend Bridge. Egg mortality would be similar under Alternative 3 and the Second Basis of Comparison (Appendix 9C, Table B-4).

Changes in Weighted Usable Area

The WUA results for winter-run Chinook Salmon spawning habitat between Keswick Dam and Battle Creek indicated that the amount of spawning habitat would be similar under Alternative 3 and the Second Basis of Comparison (Appendix 9E, Table C-17-5). Results were similar for fry rearing, (Appendix 9E, Table C-18-5). Results for juvenile rearing also were similar under both Alternative 3 and the Second Basis of Comparison (Appendix 9E, Table C-19-5).

Changes in SALMOD Output

SALMOD results indicate that potential production of winter-run Chinook Salmon under Alternative 3 would be essentially the same as under the Second Basis of Comparison. (Appendix 9D, Table B-4-21).

Changes in Delta Passage Model Output

The Delta Passage Model predicted similar estimates of annual Delta survival across the 81-year time period for winter-run Chinook Salmon between Alternative 3 and the Second Basis of Comparison (Appendix 9J). Median Delta survival was 0.354 for Alternative 3 and 0.352 for the Second Basis of Comparison.

Changes in Delta Hydrodynamics

Winter-run Chinook Salmon smolts are most abundant in the Delta during January, February, and March. On the Sacramento River near the confluence of Georgiana Slough, the median proportion of positive velocities under Alternative 3 was indistinguishable from the Second Basis of Comparison (Appendix 9K). On the San Joaquin River near the Mokelumne River confluence, the median proportion of positive velocities would be slightly higher under Alternative 3 than under the Second Basis of Comparison. In Old River downstream of the facilities, the median proportion of positive velocities would be similar under Alternative 3 and the Second Basis of Comparison in March, but would be moderately to slightly higher January and February, respectively under Alternative 3. In Old River upstream of the facilities, the median proportion of positive velocities would be slightly to moderately lower under Alternative 3 and the Second Basis of Comparison in these months. On the San Joaquin River downstream of Head of Old River, the percent of positive velocities would be similar under both alternative in January, February and March.

Changes in Junction Entrainment

Entrainment at the Georgiana Slough Junction under Alternative 3 would be almost indistinguishable from the Second Basis of Comparison (Appendix 9L). At the Head of Old River junction, median entrainment probability would be slightly lower under Alternative 3 in January and February and similar in March. At Turner Cut, median entrainment probabilities would be slightly lower under Alternative 3 relative to the Second Basis of Comparison in January and February; however, median entrainment probability would be similar in March. The median entrainment probability under Alternative 3 at Columbia Cut, Middle River, and Old River would be slightly lower from January to March relative to the Second Basis of Comparison.

Changes in Salvage

Salvage of Sacramento River-origin Chinook salmon is predicted to be substantially lower under Alternative 3 relative to the Second Basis of Comparison in January (Appendix 9M). In February salvage would be only moderately lower and slightly lower in March.

Changes in Oncorhynchus Bayesian Analysis Output

Escapement of winter-run Chinook Salmon and Delta survival was modeled by the Oncorhynchus Bayesian Analysis (OBAN) model for winter-run Chinook salmon. Differences in escapement between Alternative 3 and the Second Basis scenarios were moderately small (Appendix 9I). Escapement was generally greater under Alternative 3 relative to Second Basis of Comparison, and it was consistently greater over the 1986 to 1988 simulation period (dark gray and light gray areas above the dashed line). In most other years the difference in escapement estimates included 0 (i.e., dashed line located in the dark gray, central 0.50 probability region) (see Appendix 9I). The median delta survival was slightly higher under Alternative 3 relative to the Second Basis scenario (6 percent), although the probability of no difference between alternatives was generally high throughout the simulation time period.

Changes in Interactive Object-Oriented Simulation Output

The IOS model predicted similar adult escapement trajectories for winter-run Chinook Salmon between Alternative 3 and the Second Basis of Comparison across the 81 years (Appendix 9H). Median adult escapement under Alternative 3 was 4,025 and under the Second Basis of Comparison median escapement was 4,042.

Similar to adult escapement, the IOS model predicted similar egg survival for winter-run Chinook Salmon between Alternative 3 and the Second Basis of Comparison across the 81 water years. Median egg survival was 0.987 for both scenarios.

Summary of Effects on Winter-Run Chinook Salmon

The multiple model and analysis outputs described above characterize the anticipated conditions for winter-run Chinook Salmon and their response to change under Alternative 3 as compared to the Second Basis of Comparison. For the purpose of analyzing effects on winter-run Chinook Salmon and developing conclusions, greater reliance was placed on the outputs from the two life cycle models, IOS and OBAN because they each integrate the available information to produce single estimates of winter-run Chinook Salmon escapement. The output from IOS indicated that winter-run Chinook Salmon escapement would be similar under both scenarios, whereas the OBAN results indicated that escapement under Alternative 3 could be higher than under the Second Basis of Comparison.

These model results suggest that effects on winter-run Chinook Salmon would be similar under both scenarios, with a small likelihood that winter-run Chinook Salmon escapement would be higher under Alternative 3 than under the Second Basis of Comparison. The ocean harvest restrictions under Alternative 3 could provide additional benefit, although the effects of the predator management program are uncertain. Overall, given the small differences, distinguishing a clear difference between alternatives is difficult. The non-operational components associated with Alternative 3 could benefit winter-run Chinook Salmon relative to the Second Basis of Comparison over the short term if successful. Thus, it is concluded that the potential for adverse effects on winter-run Chinook Salmon would be slightly less under Alternative 3 than under the Second Basis of Comparison.

Spring-run Chinook Salmon

Operations under Alternative 3 generally would be similar to those for the Second Basis of Comparison. The following describes those changes and their potential effects.

Changes in Water Temperature

Long-term average monthly water temperature in the Sacramento River under Alternative 3 and the Second Basis of Comparison would be similar (Appendix 6B). Differences in the frequency of exceeding temperature thresholds under Alternative 3 and the Second Basis of Comparison also would be minor (differences of about 1 percent), as would egg mortality, which would be similar under Alternative 3 and the Second Basis of Comparison (Appendix 9C, Table B-3).

In Clear Creek, average monthly water temperature at Igo under Alternative 3 relative to the Second Basis of Comparison would be similar (Appendix 6B, Table B-3-5). The frequency of exceeding temperature thresholds for spring-run Chinook Salmon rearing also would be minor (differences of 1 percent).

In the Feather River, average monthly water temperature at the low flow channel under Alternative 3 relative to the Second Basis of Comparison also would be similar (differences less than 0.5°F), with a slight reduction in temperature (0.7°F) in August of below normal years (Appendix 6B, Table B-20-5). Water temperatures at the downstream location also would be similar, with temperatures under Alternative 3 at Robinson Riffle and Gridley up to 2°F percent cooler in July and August of some water year types (Appendix 6B, Table B-21-5). Changes in the frequency of temperature thresholds would be minor (differences of 1 percent or less), except in May when the temperature threshold for rearing would be exceeded about 4 percent more frequently than under the Second Basis of Comparison.

Changes in Weighted Usable Area

Weighted usable area curves are available for spring-run Chinook Salmon in Clear Creek. Flows in Clear Creek downstream of Whiskeytown Dam are not anticipated to differ under Alternative 3 relative to the Second Basis of Comparison. Therefore, there would be no change in the amount of potentially suitable spawning and rearing habitat for spring-run Chinook Salmon (as indexed by WUA) available under the Alternative 3 as compared to the Second Basis of Comparison.

Changes in SALMOD Output

SALMOD results indicate that potential production of spring-run Chinook Salmon would be essentially the same under Alternative 3 relative to the Second Basis of Comparison, but could be up to 8 percent less than under the Second Basis of Comparison in critical dry years (Appendix 9D, Table B-3-21).

Changes in Delta Passage Model Output

The Delta Passage Model predicted similar estimates of annual Delta survival across the 81-year time period for spring-run Chinook Salmon between Alternative 3 and the Second Basis of Comparison (Appendix 9J). Median Delta survival would be 0.286 for both scenarios.

Changes in Delta Hydrodynamics

Spring-run Chinook Salmon are most abundant in the Delta from March through May. Near the junction of Georgiana Slough, the median proportion of time that velocity would be positive was similar for both Alternative 3 and the Second Basis of Comparison in March, April and May (Appendix 9K). Near the confluence of the San Joaquin River and the Mokelumne River, the median proportion with positive velocity was similar during these months under Alternative 3 and the Second Basis of Comparison. In the San Joaquin River downstream of the Head of Old River, the median proportion of positive velocities was similar between scenarios in March, whereas values were slightly to moderately lower under Alternative 3 relative to the Second Basis of Comparison in April and May, respectively. In Old River upstream of the facilities, the median proportion with positive velocities was similar between scenarios in March and moderately higher in April and May under Alternative 3 relative to the Second Basis of Comparison. In Old River downstream of the facilities, the median proportion with positive velocities was similar between scenarios in March and slightly higher in April and May under Alternative 3 relative to the Second Basis of Comparison.

Changes in Junction Entrainment

Entrainment at the Georgiana Slough Junction under Alternative 3 would be almost indistinguishable from the Second Basis of Comparison during March April and May (Appendix 9L). At the Head of Old River junction, entrainment would be similar under Alternative 3 and the Second Basis of Comparison in March, whereas entrainment would be much greater under Alternative 3 relative to the Second Basis of Comparison in April and May. At Turner Cut, entrainment would be similar under Alternative 3 relative to the Second Basis of Comparison in March and slightly to moderately lower in April and May, respectively under Alternative 3. Entrainment at Columbia Cut, Middle River, and Old River would yield similar patterns as those observed at Turner Cut.

Changes in Salvage

Spring-run Chinook Salmon smolts migrating through the Delta would be most susceptible in the months of March, April, and May. Salvage of Sacramento River-origin Chinook salmon is predicted to be similar under Alternative 3 and the Second Basis of Comparison in March, April, and May (Appendix 9M).

Summary of Effects on Spring-Run Chinook Salmon

The multiple model and analysis outputs described above characterize the anticipated conditions for spring-run Chinook Salmon and their response to change under Alternative 3 and the Second Basis of Comparison. For the purpose of analyzing effects on spring-run Chinook Salmon in the Sacramento River, greater reliance was placed on the outputs from the SALMOD model because it integrates the available information on temperature and flows to produce estimates of mortality for each life stage and an overall, integrated estimate of potential spring-run Chinook Salmon juvenile production. The output from SALMOD indicated that spring-run Chinook Salmon production in the Sacramento River would be similar under Alternative 3 and the Second Basis of Comparison, although production under Alternative 3 could be up to 8 percent less than under the Second Basis of Comparison in critical dry years.

The analyses attempting to assess the effects on routing, entrainment, and salvage of juvenile salmonids in the Delta suggest that salvage (as an indicator of potential losses of juvenile salmon at the export facilities) of Sacramento River-origin Chinook Salmon generally would be similar under Alternative 3 and the Second Basis of Comparison.

In Clear Creek and the Feather River, the analysis of the effects of Alternative 3 and the Second Basis of Comparison for spring-run Chinook Salmon relied on output from the WUA analysis and water temperature output for Clear Creek at Igo, and in the Feather River low flow channel and downstream of the Thermalito complex. The WUA analysis suggests that there would be little difference in the availability of spawning and rearing habitat in Clear Creek. The temperature model outputs suggest that thermal conditions and effects on each of the spring-run Chinook Salmon life stages generally cannot be fully characterized in Clear Creek and the Feather River. This conclusion is supported by the water temperature threshold exceedance analysis that indicated that water temperature thresholds for spawning and egg incubation in Clear Creek and the Feather River would be exceeded less frequently in some months and more frequently in others under Alternative 3 than under the Second Basis of Comparison. The water temperature threshold for rearing spring-run Chinook Salmon in the Feather River would also be exceeded less frequently in some months and more frequently in others under Alternative 3. Because of the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), and the differences in the magnitude and direction of the temperature exceedances under

Alternative 3, the extent of temperature-related effects on spring-run Chinook Salmon in Clear Creek and the Feather River is uncertain.

These model results suggest that overall, effects on spring-run Chinook Salmon could be slightly more adverse under Alternative 3 than the Second Basis of Comparison, with a small likelihood that spring-run Chinook Salmon production would be lower under the Second Basis of Comparison. Although the operational components associated with Alternative 3 could have greater adverse effects on spring-run Chinook Salmon than the Second Basis of Comparison, the non-operational components associated with Alternative 3 could benefit spring-run Chinook Salmon relative to the Second Basis of Comparison over the short term if successful. The ocean harvest restriction component of Alternative 3 could increase spring-run Chinook Salmon numbers by reducing ocean harvest and the trap and haul program and predator control measures under Alternative 3 could reduce predation on juvenile spring-run Chinook Salmon and thereby increase survival. The effects of the trap and haul and predator management programs under Alternative 3 are uncertain. Thus, it is concluded that the potential for adverse effects on spring-run Chinook Salmon would be slightly less under Alternative 3 than under the Second Basis of Comparison.

Fall-Run Chinook Salmon

Changes in operations that influence temperature and flow conditions in the Sacramento River downstream of Keswick Dam, Clear Creek downstream of Whiskeytown Dam, Feather River downstream of Oroville Dam and American River below Nimbus could affect fall-run Chinook Salmon. The following describes those changes and their potential effects.

Changes in Water Temperature

Water temperature conditions in the Sacramento River, Clear Creek, and Feather River under Alternative 3 and the Second Basis of Comparison would be same as those described above for spring-run Chinook Salmon. Temperature conditions in the Sacramento River, Clear Creek, Feather River, and American River would generally be similar (differences less than 0.5°F) under Alternative 3 and the Second Basis of Comparison (Appendix 6B).

The frequency of exceeding established temperature thresholds in the Sacramento and Feather rivers for fall-run Chinook Salmon would be the same or nearly so (differences of up to 2 percent) for both Alternative 3 and the Second Basis of Comparison. Similarly, in the American River (Appendix 9C, Table B-6), differences in the frequency of temperature threshold exceedance would be minor (up to about 1 percent).

The results from Reclamation’s salmon mortality model reflect the similarities in temperature described above. For fall-run Chinook Salmon in the Sacramento River, egg mortality would be similar under Alternative 3 and the Second Basis of Comparison (Appendix 9C, Table B-1). Differences in the Feather and American rivers would also be similar under Alternative 3 and the Second Basis of Comparison.

Changes in Weighted Usable Area

Modeling results indicate that, in general, there would be similar amounts (less than 5 percent differences) of fall-run Chinook Salmon spawning habitat available in the Sacramento, Feather, and American rivers under Alternative 3 as compared to the Second Basis of Comparison; fall-run fry and juvenile rearing WUA would also be similar under Alternative 3 and the Second Basis of Comparison in the Sacramento River. Overall, spawning and rearing habitat availability for fall-run Chinook Salmon would be similar under Alternative 3 and the Second Basis of Comparison.

Changes in SALMOD Output

SALMOD results indicate that production for fall-run Chinook Salmon would be similar under Alternative 3 and the Second Basis of Comparison (Appendix 9D, Table B-1-21).

Changes in Delta Passage Model Output

The Delta Passage Model predicted similar estimates of annual Delta survival across the 8-year time period for fall-run Chinook Salmon between Alternative 3 and the Second Basis of Comparison (Appendix 9J). Median Delta survival was 0.246 for Alternative 3 and 0.245 for the Second Basis of Comparison.

Changes in Delta Hydrodynamics

Fall-run Chinook Salmon smolts are most abundant in the Delta during the months of April, May and June. At the junction of Georgiana Slough and the Sacramento River, the median proportion of positive velocities would be similar in April, May, and June under Alternative 3 and the Second Basis of Comparison (Appendix 9K). Near the confluence of the San Joaquin River and the Mokelumne River, the median proportion of positive velocities would be similar to or slightly lower under Alternative 3 relative to the Second Basis of Comparison in the months when fall-run Chinook Salmon are most abundant. On Old River downstream of the facilities, the median proportion of positive velocities would be slightly higher in April and May, and similar in June under Alternative 3 relative to the Second Basis of Comparison. In Old River upstream of the facilities, the median proportion of positive velocities would be moderately higher under Alternative 3 in April and May and slightly lower in June. On the San Joaquin River downstream of the Head of Old River, the median proportion of positive velocities would be slightly to moderately lower under Alternative 3 relative to the Second Basis of Comparison in April and May, respectively, and slightly lower in June.

Changes in Junction Entrainment

Entrainment at the Georgiana Slough Junction under Alternative 3 would be almost indistinguishable from the Second Basis of Comparison in April, May, and June (Appendix 9L). At the Head of Old River junction in April and May, entrainment would be much greater under Alternative 3 relative to the Second Basis of Comparison. In June, entrainment would be similar under each scenario. Patterns of entrainment would be similar at Turner Cut, Columbia Cut, Middle River, and Old River. At these junctions, median entrainment under Alternative 3 would be slightly to moderately lower in April and May, and almost indistinguishable in June.

Changes in Salvage

Salvage of Sacramento River-origin Chinook Salmon is predicted to be lower under Alternative 3 relative to the Second Basis of Comparison in every month except April, May, and June (Appendix 9M). Fall-run Chinook Salmon smolts migrating through the Delta would be most susceptible in the months of April, May, and June. Predicted values in April and May indicated a similar fraction of fish salvaged under Alternative 3 and the Second Basis of Comparison and a slightly reduce fraction salvaged in June under Alternative 3.

Summary of Effects on Fall-Run Chinook Salmon

The multiple model and analysis outputs described above characterize the anticipated conditions for fall-run Chinook Salmon and their response to change under Alternative 3 and the Second Basis of Comparison. For the purpose of analyzing effects on fall-run Chinook Salmon in the Sacramento River, greater reliance was placed on the outputs from the SALMOD model because it integrates the available information on temperature and flows to produce estimates of mortality for each life stage and an overall, integrated estimate of potential fall-run Chinook Salmon juvenile production. The output from SALMOD indicated that fall-run Chinook Salmon production would be similar in all water year types under Alternative 3 and the Second Basis of Comparison.

The analyses attempting to assess the effects on routing, entrainment, and salvage of juvenile salmonids in the Delta suggest that salvage (as an indicator of potential losses of juvenile salmon at the export facilities) of Sacramento River-origin Chinook Salmon generally would be similar under Alternative 3 and the Second Basis of Comparison.

In Clear Creek and the Feather and American rivers, the analysis of the effects of Alternative 3 and the Second Basis of Comparison for fall-run Chinook Salmon relied on the WUA analysis for habitat and water temperature model output for the rivers at various locations downstream of the CVP and SWP facilities. The WUA analysis indicated that the availability of spawning and rearing habitat in Clear Creek and spawning habitat in the Feather and American rivers would be similar under Alternative 3 and the Second Basis of Comparison. The temperature model outputs for each of the fall-run Chinook Salmon life stages suggest that thermal conditions and effects on fall-run Chinook Salmon in all of these streams generally would be similar under both scenarios. The water temperature threshold exceedance analysis that indicated that the water temperature thresholds for fall-run Chinook Salmon spawning and egg incubation would be exceeded slightly less frequently in the Feather River and Clear Creek under Alternative 3 and could reduce the potential for adverse effects on the fall-run Chinook Salmon populations in Clear Creek and the Feather River. Results of the analysis using Reclamation's salmon mortality model indicate that there would be little difference in fall-run Chinook Salmon egg mortality under Alternative 3 and the Second Basis of Comparison.

Overall, the results of the numerical models suggest the potential for less adverse effects on fall-run Chinook Salmon under Alternative 3 as compared to the Second Basis of Comparison. However, discerning a meaningful difference between these two scenarios based on the quantitative results is not possible because of the similarity in results (generally differences less than 5 percent) and the inherent uncertainty of the models. In addition, adverse effects of Alternative 3 could be offset by the potentially beneficial effects of the predator control program and ocean harvest restrictions. Thus, it is concluded that the potential for adverse effects on fall-run Chinook Salmon would be slightly less under Alternative 3 than under the Second Basis of Comparison.

Late Fall-Run Chinook Salmon

Changes in Water Temperature

Temperature conditions in the Sacramento River downstream of Keswick Dam for late fall-run Chinook Salmon under Alternative 3 and the Second Basis of Comparison generally would be similar, as described above for fall-run Chinook Salmon. The results from Reclamation’s salmon mortality model reflect the similarities in temperature described above. For late fall-run Chinook Salmon in the Sacramento River, egg mortality would be similar under Alternative 3 and the Second Basis of Comparison (Appendix 9C, Table B-1).

Changes in Weighted Usable Area

Modeling results indicate that there would be similar amounts of spawning habitat available for late fall-run Chinook Salmon in the Sacramento River from January through April under Alternative 3 as compared to the Second Basis of Comparison (Appendix 9E, Table C-14-5). There also would be similar amounts of suitable late fall-run Chinook Salmon fry rearing habitat available during April and May under Alternative 3 and the Second Basis of Comparison (Appendix 9E, Table C-15-5). Modeling results indicate that, there would generally be similar amounts of suitable juvenile rearing habitat available all year long under Alternative 3 and the Second Basis of Comparison (Appendix 9E, Table C-16-5).

Changes in SALMOD Output

Results from the SALMOD model indicate that potential production under Alternative 3 would be similar under Alternative 3 and the Second Basis of Comparison in all water year types (Appendix 9D, Table B-2-21).

Changes in Delta Passage Model Output

The Delta Passage Model predicted similar estimates of annual Delta survival across the 81-year time period for late fall-run Chinook Salmon between Alternative 3 and the Second Basis of Comparison (Appendix 9J). Median Delta survival would be 0.199 for both scenarios.

Changes in Delta Hydrodynamics

The late fall-run Chinook Salmon migration period overlaps with the winter-run. See the section on hydrodynamic analysis for winter-run Chinook Salmon for potential effects on late fall-run Chinook Salmon.

Changes in Junction Entrainment

Entrainment probabilities for late fall-run Chinook Salmon are assumed to mimic that of winter-run Chinook Salmon due to the overlap in timing. See the section on winter-run Chinook Salmon entrainment for potential effects on late fall-run Chinook Salmon.

Changes in Salvage

Salvage of late fall-run Chinook Salmon is assumed to mimic that of winter-run Chinook Salmon due to overlap in timing. See the section on winter-run Chinook Salmon entrainment for potential effects on the late fall-run Chinook Salmon.

Summary of Effects on Late Fall-Run Chinook Salmon

The multiple model and analysis outputs described above characterize the anticipated conditions for late fall-run Chinook Salmon and their response to change under Alternative 3 and the Second Basis of Comparison. For the purpose of analyzing effects on late fall-run Chinook Salmon and developing conclusions, greater reliance was placed on the outputs from the SALMOD model because it integrates the available information on temperature and flows to produce estimates of mortality for each life stage and an overall, integrated estimate of potential fall-run Chinook Salmon juvenile production. The output from SALMOD suggested that late fall-run Chinook Salmon production would be similar under Alternative 3 and the Second Basis of Comparison.

Although, potential losses of juvenile salmon at the export facilities could be higher under Alternative 3, as suggested by the analysis of salvage, it is likely that effects on the late fall-run Chinook Salmon population would be similar under Alternative 3 and the Second Basis of Comparison.

Overall, the results of the numerical models suggest the potential for less adverse effects on late fall-run Chinook Salmon under Alternative 3 as compared to the Second Basis of Comparison. However, discerning a meaningful difference between these two scenarios based on the quantitative results is not possible because of the similarity in results (generally differences less than 5 percent) and the inherent uncertainty of the models. In addition, any adverse effects of Alternative 3 could be offset by the potentially beneficial effects resulting from predator control and ocean harvest restrictions. Thus, it is concluded that the effects on late fall-run Chinook Salmon would be similar under Alternative 3 and the Second Basis of Comparison.

Steelhead

Changes in Water Temperature

Water temperature conditions in the Sacramento River, Clear Creek, Feather River and American River under Alternative 3 and the Second Basis of Comparison would be same as those described above for fall-run Chinook Salmon. Temperature conditions in the Sacramento River, Clear Creek, Feather River, and American River would generally be similar (differences less than 0.5°F) under Alternative 3 and the Second Basis of Comparison (Appendix 6B).

The frequency of exceeding temperature thresholds in the Sacramento, Feather, and American rivers for steelhead would be the same or nearly so (differences of up to 2 percent) for both Alternative 3 and the Second Basis of Comparison Exceedances.

Changes in Weighted Usable Area

Modeling results indicate that, in general, there would be similar amounts (less than 5 percent differences) of steelhead spawning habitat available in Clear Creek, and the Sacramento, Feather, and American rivers under Alternative 3 as compared to the Second Basis of Comparison.

Summary of Effects on Steelhead

The multiple model and analysis outputs described above characterize the anticipated conditions for steelhead and their response to change under Alternative 3 and the Second Basis of Comparison. The analysis of the effects of Alternative 3 and the Second Basis of Comparison for steelhead relied on the WUA analysis for habitat and water temperature model output for the rivers at various locations downstream of the CVP and SWP facilities. The WUA analysis indicated that the availability of steelhead spawning and rearing habitat in Clear Creek and steelhead spawning habitat in the Sacramento, Feather and American rivers would be similar under Alternative 3 and the Second Basis of Comparison. The temperature model outputs for each of the steelhead life stages indicated that the water temperature thresholds for steelhead spawning and egg incubation would be exceeded less frequently in the Feather River under Alternative 3. However, the water temperature threshold for steelhead rearing in the Feather River would be exceeded less frequently in some months and more frequently in others under Alternative 3. The water temperature threshold for steelhead rearing in the American River would also be exceeded more frequently in most months under Alternative 3. Because of the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), and the differences in the magnitude and direction of the temperature exceedances under Alternative 3, the extent of temperature-related effects on steelhead in the Feather and American rivers is uncertain.

Overall, the results of the numerical models suggest a slightly greater potential to result in adverse effects on steelhead under Alternative 3 as compared to the Second Basis of Comparison. However, discerning a meaningful difference between these two scenarios based on the quantitative results is not possible because of the similarity in results (generally differences less than 5 percent) and the inherent uncertainty of the models. In addition, any adverse effects of Alternative 3 could be offset by the potentially beneficial effects resulting from predator control and ocean harvest restrictions. Thus, it is concluded that the effects on steelhead would be similar under Alternative 3 and the Second Basis of Comparison.

Sturgeon (green and white)

Changes in operations that influence temperature and flow conditions could affect Green Sturgeon. The following describes those changes and their potential effects.

Changes in Water Temperature

The analysis of the effects of Alternative 3 and Second Basis of Comparison for sturgeon relied on water temperature model output for the Sacramento and Feather rivers at various locations downstream of Shasta Dam and the Thermalito complex. The temperature model outputs for each of these rivers suggest that thermal conditions and effects on sturgeon in the Sacramento and Feather rivers generally would be similar under both scenarios. This conclusion is supported by the water temperature threshold exceedance analysis that indicated that the water temperature thresholds for sturgeon spawning, incubation, and rearing would be exceeded slightly less frequently under Alternative 3 in the Sacramento River. The water temperature threshold for sturgeon spawning, incubation, and rearing also would be exceeded slightly less frequently in the Feather River.

Changes in Delta Outflow

As described in Appendix 9P, mean (March to July) Delta outflow was used an indicator of potential year class strength and the likelihood of producing a strong year class of sturgeon. The median value over the 82-year CalSim II modeling period of mean (March to July) Delta outflow was predicted to similar under the Alternative 3 and the Second Basis of Comparison. In addition, the likelihood of mean (March to July) Delta outflow exceeding the threshold of 50,000 cfs was the same under both alternatives.

Summary of Effects on Sturgeon

The slightly reduced frequency of exceedance of temperature thresholds under Alternative 3 could reduce the potential for adverse effects on sturgeon in the Sacramento and Feather rivers relative to the Second Basis of Comparison. The analysis based on Delta outflows suggests that Alternative 3 provides similar mean (March to July) outflows which would have similar effects on year class strength of juvenile sturgeon relative to the Second Basis of Comparison. Therefore, based primarily on the analysis of water temperatures, Alternative 3 could be less likely to result in adverse effects on White Sturgeon than the Second Basis of Comparison.

Delta Smelt

Changes in Proportional Entrainment

As described in Appendix 9G, a proportional entrainment regression model (based on Kimmerer 2008, 2011) was used to simulate adult Delta Smelt entrainment, as influenced by OMR flow in December through March. Results indicate that the percentage of entrainment of migrating and spawning adult Delta Smelt under Alternative 3 would be 7.3 to 8.5 percent, depending on the water year type, with a long term average percent entrainment of 7.9 percent. Percent entrainment of adult Delta Smelt under Alternative 3 would be similar to results under the Second Basis of Comparison.

As described in Appendix 9G, a proportional entrainment regression model (based on Kimmerer 2008) was used to simulate larval and early juvenile Delta Smelt entrainment, as influenced by OMR flow and location of X2 in March through June. Results indicate that the percentage of entrainment of larval and early juvenile Delta Smelt under Alternative 3 would be 5.6 to 20.5 percent, depending on the water year type, with a long term average percent entrainment of 12.7 percent, and highest entrainment under Critical water year conditions. Percent entrainment of larval and early juvenile Delta Smelt under Alternative 3 would be similar to results under the Second Basis of Comparison.

Changes in Fall Abiotic Habitat Index

The average September through December X2 position in km was used to evaluate the fall abiotic habitat availability for delta smelt under the Alternatives. X2 values simulated in the CalSim II model for each alternative were averaged over September through December, and compared. Results indicate that under the Second Basis of Comparison, the X2 position would range from 85.6 km to 92.3 km, depending on the water year type, with a long term average X2 position of 88.1 km. The most eastward location of X2 is predicted under Critical water year conditions. The X2 positions predicted under Alternative 3 would be similar to predictions under the Second Basis of Comparison (only 0.1 to 0.3 km difference). Under Alternative 3, the long term average X2 position would be 88.1 km, a location that does not provide for the advantageous overlap of the low salinity zone with Suisun Bay/Marsh.

Summary of Effects on Delta Smelt

Overall, Alternative 3 likely would have similar effects on Delta Smelt, as compared to the Second Basis of Comparison with regard to estimated entrainment and predicted location of Fall X2. However, given the current condition of the Delta Smelt population, even small differences between alternatives may be important.

Longfin Smelt

The effects of the Alternative 3 as compared to the Second Basis of Comparison were analyzed based on the direction and magnitude of OMR flows during the period (December through June) when adult, larvae, and young juvenile Longfin Smelt are present in the Delta in the vicinity of the export facilities (Appendix 5A). The analysis was augmented with calculated Longfin Smelt abundance index values (Appendix 9G) per Kimmerer et al. (2009), which is based on the assumptions that lower X2 values reflect higher flows and that transporting Longfin Smelt farther downstream leads to greater Longfin Smelt survival. The index value indicates the relative abundance of Longfin Smelt and not the calculated population.

As described in Appendix 5A, OMR flows would be negative in all months under both Alternative 3 and the Second Basis of Comparison. Flows under Alternative 3 generally would be less negative than under the Second Basis of

Comparison, except in June, July, and August, when OMR flows under Alternative 3 would be more negative by greater 25 percent in some months and year types. The increase in the magnitude of negative flows in June, July, and August under Alternative 3 could increase the likelihood of entrainment of Longfin Smelt at the export facilities.

Under Alternative 3, Longfin Smelt abundance index values range from 1,094 under critical water year conditions to a high of 15,638 under wet water year conditions, with a long-term average value of 7,345 (see Appendix 9G). Under the Second Basis of Comparison, Longfin Smelt abundance index values range from 947 under critical water year conditions to a high of 15,822 under wet water year conditions, with a long-term average value of 7,257.

Results indicate that the Longfin Smelt abundance index values would be similar in wetter years and higher in drier water year types under Alternative 3 than they would be under the Second Basis of Comparison, with a long-term average index for Alternative 3 that is 1similar to the long-term average index under the Second Basis of Comparison. The greatest increase in the Longfin Smelt abundance index occurs in critical years where it is 15.5 percent greater under Alternative 3 than under the Second Basis of Comparison. For below normal, and dry water years, the Longfin Smelt abundance index values would be 9.7 and 13.8 percent higher, respectively, under Alternative 3 than under the Second Basis of Comparison. Based on the Longfin Smelt abundance indices, Alternative 3 likely would have a lower potential for adverse effects on Longfin Smelt, as compared to the Second Basis of Comparison. Given the current condition of the Longfin Smelt population, even these small differences between alternatives may be important.

Sacramento Splittail

Under Alternative 3, flows entering the Yolo Bypass generally would similar to flows under the Second Basis of Comparison from December through March (Appendix 5A, Table C-26-5). Any differences likely would be insufficient to reduce potential Sacramento Splittail spawning habitat in the bypass. Given the relatively minor changes in flows into the Yolo Bypass, and the inherent uncertainty associated with the resolution of the CalSim II model (average monthly outputs), it is concluded that there would be no definitive difference in effects on Sacramento Splittail between Alternative 3 and the Second Basis of Comparison.

Reservoir Fishes

The analysis of effects associated with changes in operation on reservoir fishes relied on evaluation of changes in available habitat (reservoir storage) and anticipated changes in black bass nesting success.

Alternative 3 as compared to the Second Basis of Comparison generally would result in similar (differences less than 5 percent) storage levels in CVP and SWP reservoirs during the March through June period (Appendix 5A).

In general, black bass nesting success also would be similar under Alternative 3 and the Second Basis of Comparison. Nesting success of black bass would be high in March and April due to increasing water surface elevations. During May, the likelihood of high (>40 percent) nesting success would be similar in most of the reservoirs under Alternative 3 as compared to the Second Basis of Comparison. This pattern is reversed in June, with the likelihood of high nesting success being somewhat (5 to 7 percent) lower under Alternative 3 (Appendix 9F). Most black bass spawning likely occurs prior to June, such that drawdowns during June would likely affect only a small proportion of the spawning population. Thus, it is concluded that effects on black bass nesting success would be similar under Alternative 3 and the Second Basis of Comparison.

Other Species

Several other fish species could be affected by changes in operations that influence temperature and flow. In general, lampreys, Striped Bass, American Shad, and Hardhead can tolerate higher temperatures than salmonids. Based on the similar water temperatures during their spawning and incubation period under Alternative 3, it is likely that thermal conditions for and effects on these other species in the Sacramento, Feather, and American rivers would be similar under Alternative 3 and the Second Basis of Comparison. Alternative 3 would result in a similar X2 position as compared to the Second Basis of Comparison during April, May, and June (Appendix 5A, Section C Table C-16-5). This similarity in the position of X2 would likely result in a similar survival index and habitat index as measured by salinity for Striped Bass and a similar abundance and habitat index for American Shad. Alternative 3 likely would have a similar potential for adverse effects on lampreys, American Shad, and Hardhead as the Second Basis of Comparison. However, the increased bag limits and ability of anglers to retain Striped Bass that are 12 inches in length versus 18 inches under Alternative 3 could reduce the ability to meet the doubling goals for Striped Bass populations under the requirements of Section 3406(b)(1) of CVPIA. Overall, Alternative 3 likely would have slightly greater potential for adverse effects on Striped Bass as compared to the Second Basis of Comparison, primarily due to the potential for adverse effects of changing the bag and size limits for Striped Bass under the predator control program.

Stanislaus River/Lower San Joaquin River

Fall-Run Chinook Salmon

Changes in operations influence temperature and flow conditions that could affect fall-run Chinook Salmon in the Stanislaus River downstream of Goodwin Dam and in the San Joaquin River below Vernalis. The following describes those changes and their potential effects.

Changes in Water Temperature (Stanislaus River)

Average monthly water temperatures in the Stanislaus River at Goodwin Dam under Alternative 3 generally would similar to the Second Basis of Comparison but could be lower (up to 1.5°F) than under the Second Basis of Comparison in

September, October, and November of drier years (Appendix 6B, Table B-17-5). Downstream at Orange Blossom Bridge, average monthly water temperatures under Alternative 3 and the Second Basis of Comparison would generally be similar except from August through November of drier years when water temperatures could be up to up to 1.6°F cooler under Alternative 3 and in June when the average monthly water temperature could be 2.8°F warmer and up to 4.3°F warmer in wet years under Alternative 3 as compared to the Second Basis of Comparison (Appendix 6B, Table B-18-5). This temperature pattern would continue downstream to the confluence with the San Joaquin River, although the magnitude of temperature differences under Alternative 3 (Appendix 6B, Table B-19-5) would be larger in June and water temperatures could be up to 1.6°F cooler in April under Alternative 3 as compared to the Second Basis of Comparison. Lower fall water temperatures in drier years would reduce the likelihood of adverse effects on spawning fall-run Chinook Salmon.

Changes in Exceedance of Water Temperature Thresholds (Stanislaus River)

While specific water temperature thresholds for fall-run Chinook Salmon in the Stanislaus River are not established, temperatures generally suitable for fall-run Chinook Salmon spawning (56°F) would be exceeded in October (over 30 percent of the time) and November over 20 percent of the time in the Stanislaus River at Goodwin Dam under Alternative 3 (Appendix 6B, Table B-17-1). Similar exceedances would occur under the Second Basis of Comparison. Water temperatures for rearing generally would be below 56°F, except in May.

Downstream at Orange Blossom Bridge, water temperatures suitable for fall-run Chinook Salmon spawning would be exceeded frequently under both Alternative 3 and the Second Basis of Comparison during October and November, but the 56°F threshold would be exceeded 2 percent more frequently in October and 4 percent less frequently in November percent.

During January through May, rearing fall-run Chinook Salmon under Alternative 3 and the Second Basis of Comparison would be subjected to average monthly water temperatures that exceed 56°F, with water temperatures under Alternative 3 exceeding the threshold in April about 4 percent less frequently and about 7 percent more frequently in May than under the Second Basis of Comparison (Appendix 6B, Figure B-18-5).

Changes in Egg Mortality (Stanislaus River)

For fall-run Chinook Salmon in the Stanislaus River, egg mortality rates would be similar under both scenarios (Appendix 9C, Table B-8).

Changes in Delta Hydrodynamics

San Joaquin River-origin fall-run Chinook Salmon smolts are most abundant in the Delta during the months of April, May and June. Near the confluence of the San Joaquin River and the Mokelumne River, the median proportion of positive velocities would be similar to or slightly lower under Alternative 3 relative to the Second Basis of Comparison in the months when fall-run would be most abundant

(Appendix 9K). On Old River downstream of the facilities, the median proportion of positive velocities would be slightly higher in April and May, and similar in June under Alternative 3 relative to the Second Basis of Comparison. In Old River upstream of the facilities, the median proportion of positive velocities would be moderately higher under Alternative 3 in April and May, and slightly lower in June. On the San Joaquin River downstream of the Head of Old River, the median proportion of positive velocities would be slightly to moderately lower under Alternative 3 relative to the Second Basis of Comparison in April and May, respectively, and slightly lower in June.

Changes in Junction Entrainment

Entrainment at the Georgiana Slough Junction under Alternative 3 would be almost indistinguishable from the Second Basis of Comparison in April, May, and June (Appendix 9L). At the Head of Old River junction in April and May, entrainment would be much greater under Alternative 3 relative to the Second Basis of Comparison (Appendix 9L). In June, entrainment would be similar under each scenario. Patterns of entrainment would be similar at Turner Cut, Columbia Cut, Middle River, and Old River. At these junctions, median entrainment under Alternative 3 would be slightly to moderately lower in April and May, and almost indistinguishable in June.

Summary of Effects on Fall-Run Chinook Salmon

The analysis of temperatures indicates somewhat similar temperatures and a similar likelihood of exceedance of suitable temperatures for spawning and rearing of fall-run Chinook Salmon under Alternative 3 as compared to the Second Basis of Comparison in the Stanislaus River below Goodwin Dam and in the San Joaquin River at Vernalis. The effect of lower temperatures is reflected in the similar overall mortality of fall-run Chinook Salmon eggs predicted by Reclamation’s salmon mortality model for fall-run in the Stanislaus River.

Overall, Alternative 3 likely would have similar effects on the fall-run Chinook Salmon population in the San Joaquin River watershed as compared to the Second Basis of Comparison. Alternative 3 could also provide beneficial effects to juvenile fall-run Chinook Salmon as a result of trap and haul passage through the Delta and ocean harvest restrictions. It remains uncertain, however, if predator management actions under Alternative 3 would benefit fall-run Chinook Salmon.

Steelhead

Changes in operations that influence temperature and flow conditions in the Stanislaus River downstream of Goodwin Dam and the San Joaquin River below Vernalis could affect steelhead. The following describes those changes and their potential effects.

Changes in Water Temperature (Stanislaus River)

Average monthly water temperatures in the Stanislaus River at Goodwin Dam under Alternative 3 generally would similar to the Second Basis of Comparison but could be lower (up to 1.5°F) than under the Second Basis of Comparison in September, October, and November of drier years. Downstream at Orange

Blossom Bridge, average monthly water temperatures under Alternative 3 and the Second Basis of Comparison would generally be similar except from August through November of drier years when water temperatures could be up to up to 1.6°F cooler under Alternative 3 and in June when the average monthly water temperature could be 2.8°F warmer and up to 4.3°F warmer in drier years under Alternative 3 as compared to the Second Basis of Comparison. This temperature pattern would continue downstream to the confluence with the San Joaquin River, although the magnitude of temperature differences under Alternative 3 would be larger in June and water temperatures could be up to 1.6°F cooler in April under Alternative 3 as compared to the Second Basis of Comparison.

Changes in Exceedance of Water Temperature Thresholds (Stanislaus River)

Average monthly water temperatures in the Stanislaus River at Orange Blossom Bridge would frequently exceed the temperature threshold (56°F) established for adult steelhead migration under both Alternative 3 and the Second Basis of Comparison during October and November, with the threshold being exceeded 2 percent more frequently in October and 4 percent less frequently in November percent. In January through May, the temperature threshold at Orange Blossom Bridge is 55°F, which is intended to support steelhead spawning. Under Alternative 3, this threshold would be exceeded under Alternative 3 about 8 percent and 10 percent more frequently in March and May, respectively, than under the Second Basis of Comparison. However, the threshold would be exceeded 16 percent less frequently under Alternative 3 in April.

During June through November, the temperature threshold of 65°F established to support steelhead rearing would be exceeded under both Alternative 3 and the Second Basis of Comparison in all months but November, with the highest frequency of exceedance in July (19 percent under Alternative 3). The differences between Alternative 3 and the Second Basis of Comparison, however, would be variable depending on the month, with water temperatures under Alternative 3 exceeding the threshold 2 percent to 4 percent more frequently than under the Second Basis of Comparison in June and July and up to 4 percent less frequently from August to October.

Average monthly water temperatures also would exceed the threshold (52°F) established for smoltification at Knights Ferry from January through May under both Alternative 3 and the Second Basis of Comparison. Differences in the likelihood of threshold exceedance between scenarios would be small (up to 3 percent) with the threshold being more likely to be exceeded in March and less likely to be exceeded in April and May. Farther downstream at Orange Blossom Bridge, the temperature threshold for smoltification is higher (57°F). Under Alternative 3, water temperatures would exceed the 57°F threshold about 4 percent less frequently in April and about 7 percent more frequently than under the Second Basis of Comparison in May.

Changes in Delta Hydrodynamics

San Joaquin River-origin steelhead generally move through the Delta during spring; however, there is less information on their timing than there is for Chinook salmon. Thus, hydrodynamics in the entire January through June period could have the potential to affect juvenile steelhead. For a description of potential hydrodynamic effects on steelhead, see the descriptions for winter-run Chinook Salmon in the Sacramento Basin and fall-run Chinook Salmon in the San Joaquin River basin, above.

Summary of Effects on Steelhead

Given the frequency of exceedance under both Alternative 3 and the Second Basis of Comparison, water temperature conditions for steelhead in the Stanislaus River would likely be similar. The differences in temperature exceedance would be variable (both positive and negative) between Alternative 3 and the Second Basis of Comparison, with no clear benefit associated with either alternative. Discerning a meaningful difference between these two scenarios based on the quantitative results is not possible because of the similarity in results (generally differences less than 5 percent) and the inherent uncertainty of the models. Thus, it is concluded that the effects on steelhead would be similar under Alternative 3 and the Second Basis of Comparison.

White Sturgeon

Evidence of White Sturgeon spawning has been recorded in the San Joaquin River upstream of the confluence with the Stanislaus River. While flows in the San Joaquin River upstream of the Stanislaus River are expected be similar under all alternatives, flow contributions from the Stanislaus River could influence water temperatures in the San Joaquin River where White Sturgeon eggs or larvae may occur during the spring and early summer. The magnitude of influence on water temperature would depend on the proportional flow contribution of the Stanislaus River and the temperatures in both the Stanislaus and San Joaquin rivers. The potential for an effect on White Sturgeon eggs and larvae would be influenced by the proportion of the population occurring in the San Joaquin River. In consideration of this uncertainty, it is not possible to distinguish potential effects on White Sturgeon between alternatives.

Reservoir Fishes

Changes in Available Habitat (Storage)

As described in Chapter 5, Surface Water Resources and Water Supplies, storage levels in New Melones Reservoir would be higher under Alternative 3 as compared to the Second Basis of Comparison, as summarized in Table 5.38, due to higher allocations of water supplies to CVP water service contractors, less fisheries flows, no water quality releases under SWRCB D-1641, and no Bay-Delta flow releases under SWRCB D-1641.

Storage in New Melones could be increased up to around 20 percent in some months of some water year types. Additional information related to monthly reservoir elevations is provided in Appendix 5A, CalSim II and DSM2 Modeling. It is anticipated that aquatic habitat within New Melones is not limiting; however, storage volume is an indicator of how much habitat is available to fish species inhabiting these reservoirs. Therefore, the amount of habitat for reservoir fishes could be increased under Alternative 3 as compared to the Second Basis of Comparison.

Changes in Black Bass Nesting Success

Results of the bass nesting success analysis are presented in Appendix 9F, Reservoir Fish Analysis Documentation. For March, the likelihood of Largemouth Bass and Smallmouth Bass nest survival in New Melones being above 40 percent is similar under Alternative 3 and the Second Basis of Comparison. For April, the likelihood that nest survival of Largemouth Bass and Smallmouth Bass is between 40 and 100 percent is reasonably high (around 80 percent) but is about 5 percent lower under Alternative 3 as compared to the Second Basis of Comparison. For May, the pattern is reversed with the likelihood of high nest survival being about 7 percent greater under Alternative 3. For June, the likelihood of survival being greater than 40 percent for Largemouth Bass and Smallmouth Bass in New Melones is about 38 percent greater under Alternative 3 as compared to the Second Basis of Comparison. For Spotted Bass, nest survival from March through June is anticipated to be near 100 percent in every year under both Alternative 3 and the Second Basis of Comparison. Most black bass spawning likely occurs prior to June, such that drawdowns during June would likely affect only a small proportion of the spawning population. Thus, it is concluded that effects on black bass nesting success would be similar under Alternative 3 and the Second Basis of Comparison.

The analysis of black bass nest survival based on changes in water surface elevation during the spawning period indicated that the likelihood of high (>40 percent) nest survival in New Melones under Alternative 3 would be similar to or higher than under the Second Basis of Comparison. This suggests that conditions in New Melones could be more likely to support self-sustaining populations of black bass under Alternative 3 than under the Second Basis of Comparison.

Other Species

Changes in operations that influence temperature and flow conditions in the Stanislaus River downstream of Goodwin Dam and the San Joaquin River at Vernalis could affect other species such as lampreys, Hardhead, and Striped Bass. As described above, water temperatures would generally be similar under Alternative 3 and the Second Basis of Comparison. In general, lampreys, Striped Bass and Hardhead can tolerate higher temperatures than salmonids. Given the similar flows and temperatures during their spawning and incubation period, it is likely that the potential to affect these species in the Stanislaus and San Joaquin rivers would be similar under Alternative 3 and the Second Basis of Comparison. However, the increased bag limits and ability of anglers to retain Striped Bass that are 12 inches in length versus 18 inches under Alternative 3 could reduce the ability to meet the doubling goals for Striped Bass populations under the requirements of Section 3406(b)(1) of CVPIA.

San Francisco Bay Area Region

Killer Whale

As described above for the comparison of Alternative 1 to the No Action Alternative, it is unlikely that the Chinook Salmon prey base of killer whales, supported heavily by hatchery production of fall-run Chinook Salmon, would be appreciably affected by any of the alternatives.

9.4.3.5 Alternative 4

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, as described in Chapter 3, Description of Alternatives. Alternative 4 also includes the following items that are not included in the No Action Alternative or the Second Basis of Comparison and would affect fish and aquatic resources.

- Implement predator control programs for black bass, Striped Bass, and Pikeminnow to protect salmonids and Delta Smelt as follows:
  - Black bass catch limit changed to allow catch of 12-inch fish with a bag limit of 10
  - Striped Bass catch limit changed to allow catch of 12-inch fish with a bag limit of 5
  - Establish a Pikeminnow sport-fishing reward program with a 8-inch limit at $2/fish
- Establish a trap and haul program for juvenile salmonids entering the Delta from the San Joaquin River in March through June as follows:
  - Begin operation of downstream migrant fish traps upstream of the Head of Old River on the San Joaquin River
  - "Barge" all captured juvenile salmonids through the Delta, release at Chipps Island.
  - Tag subset of fish in order to quantify effectiveness of the program
  - Attempt to capture 10 percent to 20 percent of outmigrating juvenile salmonids
- Work with Pacific Fisheries Management Council, CDFW, and NMFS to impose salmon harvest restrictions to reduce by-catch of winter-run and spring-run Chinook Salmon to less than 10 percent of age-3 cohort in all years

As described in Chapter 4, Approach to Environmental Analysis, Alternative 4 is compared to the No Action Alternative and the Second Basis of Comparison.

9.4.3.5.1 Alternative 4 Compared to the No Action Alternative

Trinity River Region

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 aquatic resources at Trinity Lake and along the Trinity

River and lower Klamath River under Alternative 4 as compared to the No Action Alternative would be the same as the impacts described in Section 10.4.4.2.1, Alternative 1 Compared to the No Action Alternative.

Central Valley Region and Stanislaus River

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 aquatic habitat conditions at CVP and SWP reservoirs, in the rivers downstream of the reservoirs, and in the Delta under Alternative 4 as compared to the No Action Alternative would be the same as the impacts described in Section 9.4.3.2.1, Alternative 1 Compared to the No Action Alternative.

Conditions related to salmonid survival could be improved under Alternative 4 as compared to the No Action Alternative due to implementation of changes in Striped Bass bag limits for predator control and changes in PMFC/NMFS harvest limits. However, these benefits would not likely exceed those described for the No Action Alternative, particularly in consideration of the provision of fish passage upstream of Shasta and Folsom dams to address long-term temperature challenges on listed salmonids caused by climate change.

Conditions for Striped Bass under Alternative 4 could be influenced by implementation of a predator control program that reduces the size restrictions and increases the catch limit for Striped Bass taken in the sport fishery. This also could reduce the ability to meet the doubling goals for Striped Bass populations under the requirements of Section 3406(b)(1) of CVPIA.

San Francisco Bay Area Region

Killer Whale

As described above the comparison of Alternative 1 to the No Action Alternative, it is unlikely that the Chinook Salmon prey base of killer whales, supported heavily by hatchery production of fall-run Chinook Salmon, would be appreciably affected by any of the alternatives.

9.4.3.5.2 Alternative 4 Compared to the Second Basis of Comparison

Trinity River Region

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, aquatic resources conditions at Trinity Lake and along the Trinity River and lower Klamath River under Alternative 4 be the same as under the Second Basis of Comparison.

Central Valley Region and Stanislaus River

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 aquatic habitat conditions at CVP and SWP reservoirs, in the rivers downstream of the reservoirs, and in the Delta due to operations under

Alternative 4 would be the same as described for the Second Basis of Comparison.

Conditions related to salmonid survival could be improved under Alternative 4 as compared to the Second Basis of Comparison due to implementation of the Trap and Haul Program, changes in bag limits, and changes in PMFC/NMFS harvest limits. Conditions related to year class strength of juvenile sturgeon would be the same under the Alternative 4 relative to the Second Basis of Comparison due to similar reductions in mean (March to July) Delta outflow. Conditions for Striped Bass under Alternative 4 would be the same as those described above for the comparison to the No Action Alternative.

However, it should be noted that the changes in ocean harvest limits under Alternative 4 could be inconsistent with NMFS' fisheries management framework for reducing the impact of ocean salmon fishery on winter-run Chinook Salmon for the Pacific Coast Salmon Fishery Management Plan (National Marine Fisheries Service 2012). The framework consists of two components. The first component specifies that the previous standards for winter-run Chinook Salmon regarding minimum size limits and seasonal windows south of Point Arena for both the commercial and recreational fisheries will continue to remain in effect at all times regardless of abundance estimates or impact rate limit. The second component is based on the population status of winter-run Chinook Salmon where, during periods of relatively low abundance, the proposed structure of fishing management measures each year for winter-run Chinook Salmon south of Point Arena must be equal to or less than the maximum allowable impact rate (MAIR) specified annually. The fishery control rule and tiered approach for managing impacts to winter-run Chinook Salmon in the ocean salmon fishery include: (1) if the geometric mean of the most recent 3 years of spawning return estimates is less than 500, the MAIR is zero percent; and (2) if the geometric mean of the most recent 3 years of spawning return estimates is between 500 and 4,000, the MAIR is between 10 percent and 20 percent, increasing linearly.

If Alternative 4 were selected, Reclamation would be required to re-consult with NMFS regarding all aspects of the alternative that could result in the take of listed salmonids before implementation, including the provisions of the proposed changes in harvest limits.

Killer Whale

As described above for the comparison of Alternative 1 to the No Action Alternative, it is unlikely that the Chinook Salmon prey base of killer whales, supported heavily by hatchery production of fall-run Chinook Salmon, would be appreciably affected by any of the alternatives.

9.4.3.6 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 OMR 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.

Alternative 5 also includes the Delta Cross Channel Temporary Closure Multi-year Study. As noted in the Finding of No Significant Impact (FONSI) document from Reclamation (Reclamation, 2012), this study proposes closing the DCC for up to 10 days during the first half of October from 2012 through 2016. The FONSI also notes that the DCC closure would not cause any adverse effects to the native aquatic and fisheries. Therefore, the effects of this study are not considered any further in the impact analyses for Alternative 5 below.

9.4.3.6.1 Alternative 5 Compared to the No Action Alternative

Because of the considerable similarities between Alternative 5 and the No Action Alternative, the analysis below combines species within some regions where to reduce repetition.

Trinity River Region

Coho Salmon, Spring-run Chinook Salmon, Fall-run Chinook Salmon, Steelhead, and Green Sturgeon

Average monthly water temperature in the Trinity River at Lewiston Dam under Alternative 5 would be similar to water temperatures under the No Action Alternative (less than 0.5°F differences) in all months (Appendix 6B, Table B-1-3). Similarly, the differences in the frequency with which Alternative 5 and the No Action Alternative would exceed established temperature thresholds also would be small (up to 1 or 2 percent) (Appendix 9N). These temperature results are reflected in the egg mortality results for fall-run Chinook Salmon in the Trinity River, which indicate similar mortality under Alternative 5 and the No Action Alternative (Appendix 9C, Table B-5).

The minor differences in temperature and mortality results suggest that conditions for Coho Salmon, spring-run Chinook Salmon, fall-run Chinook Salmon, steelhead and Green Sturgeon in the Trinity River generally would be similar under Alternative 5 and the No Action Alternative. Given the similarity of the results and the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), it is concluded that Alternative 5 and the No Action Alternative are likely to have similar effects on salmonids and sturgeon in the Trinity River.

Reservoir Fishes

Reservoir fishes in Trinity Lake would be exposed to relatively minor differences in storage (less than 5 percent) under Alternative 5 (Appendix 5A) as compared to the No Action Alternative and these relatively small differences likely would have little effect on the amount of habitat available for these species. Black bass nesting survival would be similar under Alternative 5 and the No Action Alternative (Appendix 9F). The minor differences in storage and similar nesting success suggest that effects on reservoir fishes in Trinity Lake would be similar under Alternative 5 and the No Action Alternative.

Other Species

The minor differences in average monthly water temperatures described above for salmonids apply to Pacific Lamprey and Eulachon. These minor differences suggest that conditions for aquatic species in the Trinity River and Klamath River downstream of the confluence generally would be similar under Alternative 5 and the No Action Alternative. Given the similarity of the results and the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), it is concluded that Alternative 5 and the No Action Alternative are likely to have similar effects on the lamprey and Eulachon in the Trinity River.

Sacramento River System

Winter-run Chinook Salmon

Changes in operations that influence temperature and flow conditions in the Sacramento River downstream of Keswick Dam could affect winter-run Chinook Salmon. The following describes those changes and their potential effects.

Changes in Water Temperature

Monthly water temperature in the Sacramento River at Keswick Dam under Alternative 5 and the No Action Alternative would be similar (differences of less than 0.5°F) (Appendix 6B, Table B-5-3). Differences in the frequency of exceeding temperature thresholds under Alternative 5 and the No Action Alternative also would be small (less than 3 percent) (Appendix 9N). The differences in water temperatures and temperature threshold exceedances predicted at locations in the downstream reaches are similar to those predicted at Keswick Dam. Egg mortality is anticipated to be similar under Alternative 5 and the No Action Alternative (Appendix 9C, Table B-4).

Changes in Weighted Usable Area

The WUA results for winter-run Chinook Salmon spawning habitat between Keswick Dam and Battle Creek indicated that available spawning habitat under Alternative 5 and the No Action Alternative would be similar (less than 5 percent difference) (Appendix 9E, Table C-17-3). The results were similar for fry and juvenile rearing (Appendix 9E, Table C-18-3 and Table C-19-3).

Changes in SALMOD Output

SALMOD results indicated that potential juvenile production under Alternative 5 would be the similar to the No Action Alternative in all water year types (Appendix 9D, Table B-4-11).

Changes in Delta Passage Model Output

The Delta Passage Model predicted similar estimates of annual Delta survival across the 81-year time period for winter-run Chinook Salmon between Alternative 5 and the No Action Alternative (Appendix 9J). Median Delta survival was 0.35 for Alternative 5 and 0.349 for the No Action Alternative.

Changes in Delta Hydrodynamics

Winter-run Chinook Salmon smolts are most abundant in the Delta during January, February and March. On the Sacramento River near the confluence of Georgiana Slough, the median proportion of positive velocities under Alternative 5 were indistinguishable from the No Action Alternative in January, February and March (Appendix 9K). On the San Joaquin River near the Mokelumne River confluence, the median proportion of positive velocities also was indistinguishable between these two scenarios. In Old River, both upstream and downstream of the facilities, the median proportion of positive velocities was indistinguishable in the months when winter run Chinook Salmon are present. On the San Joaquin River downstream of the Head of Old River, there was no discernable difference in the median proportion of positive velocities between these two scenarios.

Changes in Junction Entrainment

For all junctions examined, the median entrainment probabilities under both Alternative 5 and the No Action Alternative were almost indistinguishable (Appendix 9L).

Changes in Salvage

There were no discernable differences in predicted salvage between Alternative 5 and No Action Alternative (Appendix 9M).

Changes in Oncorhynchus Bayesian Analysis Output

Escapement and Delta survival was modeled by the OBAN model for winter-run Chinook salmon. Escapement was similar under Alternative 5 as compared to the No Action Alternative (Appendix 9I) as was through-Delta survival.

Changes in Interactive Object-Oriented Simulation Output

The IOS model predicted similar adult escapement trajectories for winter-run Chinook Salmon between Alternative 5 and the No Action Alternative across the 81 water years (Appendix 9H). Alternative 5 median adult escapement was 3,545 and No Action Alternative median escapement was 3,935.

Similar to adult escapement, the IOS model predicted similar egg survival for winter-run Chinook Salmon between Alternative 5 and the No Action Alternative across the 81 water years (Appendix 9H). Median egg survival was 0.989 for Alternative 5 and 0.990 for the No Action Alternative.

Summary of Effects on Winter-Run Chinook Salmon

The analysis of temperatures suggested that the frequency of temperature threshold exceedance under Alternative 5 would be similar to the No Action Alternative. This was reflected in Reclamation’s salmon mortality model results, which predicted egg mortality would be similar under Alternative 5 and the No Action Alternative. The analysis of flow changes under Alternative 5 suggested that availability of spawning habitat for winter-run Chinook Salmon would similar under Alternative 5 and the No Action Alternative; SALMOD also indicated that there would be similar juvenile production under these two alternatives. Through Delta survival of juvenile winter-run Chinook Salmon would be the same under both Alternative 5 and the No Action Alternative as indicated by the DPM and the OBAN results. Median adult escapement to the Sacramento River would be similar under Alternative 5 and the No Action Alternative as indicated by the IOS and OBAN model results. Additional analyses attempting to assess the effects on routing, entrainment and salvage of juvenile salmonids in the Delta all indicate the effects would be similar between Alternative 5 and the No Action Alternative.

Given the similarity of the results and the inherent uncertainty associated with the resolution of the models, it is concluded that Alternative 5 and the No Action Alternative are likely to have similar effects on the winter-run Chinook Salmon in the Sacramento River and Delta.

Spring-run Chinook Salmon, Fall-run Chinook Salmon, Late Fall-run Chinook Salmon, Steelhead, Green Sturgeon and White Sturgeon

Changes in Water Temperature

Average monthly water temperatures in the Sacramento River under Alternative 5 and the No Action Alternative would be similar (differences of less than 0.5°F) (Appendix 6B, Table B-5-3). Differences in the frequency of exceeding temperature thresholds under Alternative 5 and the No Action Alternative would be relatively small (differences less than 2 percent) for the spring-run, fall-run, and late fall-run Chinook Salmon, steelhead, and sturgeon in the Sacramento River (Appendix 9N).

In Clear Creek, average monthly water temperatures at Igo under Alternative 5 relative to the No Action Alternative would be similar (differences less than 0.5°F) (Appendix 6B, Table B-3-3). The frequency of exceeding temperature thresholds for spring-run Chinook Salmon rearing also would be small (differences of up to 1 percent) (Appendix 9N).

In the Feather River, average monthly water temperatures in the low flow channel under Alternative 5 relative to the No Action Alternative would be similar (differences less than 0.5°F) (Appendix 6B, Table B-20-3). Water temperatures at the downstream location also would be similar. Changes in the frequency of exceeding temperature thresholds would be relatively small (differences of 2 percent or less) between the two scenarios for the fall-run Chinook Salmon, spring-run Chinook Salmon, steelhead, and Green Sturgeon.

In the American River at Watt Avenue, average monthly water temperatures under Alternative 5 and the No Action Alternative would be similar (differences less than 0.5°F) (Appendix 6B, Table B-13-3). Changes in the frequency of exceeding temperature thresholds would be small (differences of 1 percent or less) between the two scenarios for fall-run Chinook Salmon and steelhead.

Egg mortality for all races Chinook Salmon within the Sacramento River system was predicted to be similar under Alternative 5 and the No Action Alternative (Appendix 9C, Tables B-1, B-6 and B-7).

Changes in SALMOD Output

SALMOD results indicated that potential spring-run Chinook Salmon juvenile production under Alternative 5 would be the similar to the No Action Alternative in all water year types (Appendix 9D, Table B-3-11).

Changes in Delta Passage Model Output

The Delta Passage Model predicted similar estimates of annual Delta survival across the 81-year time period for spring-run, fall-run and late fall-run Chinook Salmon between Alternative 5 and the No Action Alternative (Appendix 9J).

Changes in Delta Hydrodynamics

As described in Appendix 9K, the median proportion of time that velocity was positive at various junctions in the Delta were projected to be similar under Alternative 5 compared to the No Action Alternative.

Changes in Junction Entrainment

As described in Appendix 9L, median entrainment at various junctions is indistinguishable or lower under Alternative 5 compared to the No Action Alternative for fall-run, late fall-run, and spring-run Chinook Salmon.

Changes in Salvage

As described in Appendix 9M, salvage of migrating spring-run, late-fall run and fall-run smolts is similar or lower under Alternative 5 compared to the No Action Alternative.

Changes in Delta Outflow

As described in Appendix 9P, mean (March to July) Delta outflow was used an indicator of potential year class strength and the likelihood of producing a strong year class of sturgeon. The median value over the 82-year CalSim II modeling period of mean (March to July) Delta outflow was predicted to be similar under the Alternative 5 and the No Action Alternative. In addition, the likelihood of mean (March to July) Delta outflow exceeding the threshold of 50,000 cfs was the same under both alternatives.

Summary of Effects on Spring-run Chinook Salmon, Fall-run Chinook Salmon, Late Fall-run Chinook Salmon, Steelhead, Green Sturgeon and White Sturgeon

The analysis of temperatures indicates similar temperatures and likelihood of exceedance of temperature thresholds under Alternative 5 as compared to the No Action Alternative in the Clear Creek, and the Sacramento, Feather, and American rivers. This was reflected in Reclamation's salmon mortality model results for the fall-run on the Sacramento, Feather and American rivers which predicted similar Chinook Salmon mortalities under Alternative 5 and the No Action Alternative. There would be no change in flows in Clear Creek and Feather River low flow channel. Flows are expected to be similar in Sacramento River and American River. Flows in May in the Feather River are reduced (Appendix 5A). However, most of the spawning habitat in the Feather River is in the low flow channel; therefore, this reduction in May flow would only have minor effect on the availability of the habitat. SALMOD results indicate that the potential production for the fall-run, late fall-run and spring-run Chinook Salmon on the Sacramento River would be similar. Delta survival is expected to be similar as indicated by the Delta Passage Model and OBAN results, and the entrainment risk would be lower based on the expected changes in OMR flows under Alternative 5. Additional analyses attempting to assess the effects on routing, entrainment and salvage of juvenile salmonids in the Delta all indicate the effects would be similar under Alternative 5 and the No Action Alternative. The analysis based on Delta outflows suggests that Alternative 5 provides similar mean (March to July) outflows which would have similar effects on year class strength of juvenile sturgeon relative to the No Action Alternative.

Given the similarity of the results and the inherent uncertainty associated with the resolution of the models, it is concluded that Alternative 5 and the No Action Alternative are likely to have similar effects on salmonids and sturgeon in the Sacramento River and Delta.

Delta Smelt

A proportional entrainment regression model (based on Kimmerer 2008, 2011) was used to simulate adult Delta Smelt entrainment, as influenced by OMR flow in December through March. Results indicate that the percentage of entrainment of migrating and spawning adult Delta Smelt under Alternative 5 will be nearly identical to the results estimated for the No Action Alternative in all water year types.

A proportional entrainment regression model (based on Kimmerer 2008) also was used to simulate larval and early juvenile Delta Smelt entrainment, as influenced by OMR flow and location of X2 in March through June. Results indicate that the percentage of entrainment of larval and early juvenile Delta Smelt under Alternative 5 would be similar to that estimated for the No Action Alternative.

The average September through December X2 position in km was used to evaluate the fall abiotic habitat availability for delta smelt under the Alternatives. X2 values simulated in the CalSim II model for each alternative were averaged over September through December, and compared. Results indicate that fall X2 values under Alternative 5 would be nearly identical to the No Action Alternative.

Given the similarity of the results and the inherent uncertainty associated with the resolution of the models, it is concluded that Alternative 5 and the No Action Alternative are likely to have similar effects on Delta Smelt.

Longfin Smelt

The effects of the Alternative 5 as compared to the No Action Alternative were analyzed based on the direction and magnitude of OMR flows during the period (December through June) when adult, larvae, and young juvenile Longfin Smelt are present in the Delta in the vicinity of the export facilities (Appendix 5A). The analysis was augmented with calculated Longfin Smelt abundance index values (Appendix 9G) per Kimmerer et al. (2009), which is based on the assumptions that lower X2 values reflect higher flows and that transporting Longfin Smelt farther downstream leads to greater Longfin Smelt survival. The index value indicates the relative abundance of Longfin Smelt and not the calculated population.

OMR flows generally would be negative in all months under both scenarios, except in April and May when the long-term average would positive. Flows under Alternative 5 during these two months would be more positive than under the No Action Alternative, especially in dry and critical years when OMR flows under Alternative 5 would be positive and flows under the No Action Alternative would be negative. Differences in OMR flow during April and May under Alternative 5 would up to about 1,350 cfs more positive than under the No Action Alternative.

Longfin Smelt abundance index values were calculated for long-term average conditions and for each water year type for the different alternatives (see Appendix 9G). Under Alternative 5, Longfin Smelt abundance index values range from 1,204 under critical water year conditions to a high of 16,683 under wet water year conditions, with a long-term average value of 8,015 (Appendix 9G). Under the No Action Alternative, Longfin Smelt abundance index values range from 1,147 under critical water year conditions to a high of 16,635 under wet water year conditions, with a long-term average value of 7,951.

Results indicate that the Longfin Smelt abundance index values would be similar in all but critical years under Alternative 5 than they would be under the No Action Alternative. In critical water years, the Longfin Smelt abundance index value would be about 5 percent higher under Alternative 5 than it would be under the No Action Alternative.

Given the similarity of the results and the inherent uncertainty associated with the resolution of the models, it is concluded that Alternative 5 and the No Action Alternative are likely to have similar effects on Longfin Smelt.

Sacramento Splittail

Under Alternative 5, flows entering the Yolo Bypass over the Fremont Weir generally would be similar to the No Action Alternative (Appendix 5A, Table C-26-3), thus providing similar value to Sacramento Splittail because of the similar area of potential habitat (inundation) and the similar frequency of inundation. Given the relatively minor changes in flows into the Yolo Bypass, and the inherent uncertainty associated with the resolution of the CalSim II model (average monthly outputs), it is concluded that there would be no definitive difference in effects on Sacramento Splittail between Alternative 5 and the No Action Alternative.

Reservoir Fishes

The analysis of effects associated with changes in operation on reservoir fishes relied on evaluation of changes in available habitat (reservoir storage) and anticipated changes in black bass nesting success.

Changes in CVP and SWP water supplies and operations under Alternative 5 as compared to the No Action Alternative generally would result in similar reservoir storage in CVP and SWP reservoirs in the Central Valley Region (Appendix 5A). Storage levels in Shasta Lake, Lake Oroville, and Folsom Lake would be similar under Alternative 5 as compared to the No Action Alternative. Additional information related to monthly reservoir elevations is provided in Appendix 5A, CalSim II and DSM2 Modeling.

In general, black bass nesting success would be similar under Alternative 5 and the No Action Alternative (Appendix 9F). Nesting success of black bass would be high in March and April due to increasing water surface elevations. During May and June, the likelihood of high (>40 percent) nesting success would be similar in most of the reservoirs under Alternative 5 as compared to the No Action Alternative (Appendix 9F). Therefore, it is concluded that the effects on black bass species would be similar under both Alternative 5 and the No Action Alternative.

Other Species

Several other fish species could be affected by changes in operations that influence temperature and flow. In general, lampreys, Striped Bass, American Shad, and Hardhead can tolerate higher temperatures than salmonids. Based on the generally similar water temperatures during their spawning and incubation period under Alternative 5, it is likely that thermal conditions for and effects on these other species in the Sacramento, Feather, and American rivers would be similar under Alternative 5 and the No Action Alternative. Alternative 5 would result in a similar X2 position as compared to the No Action Alternative during April, May, and June (Appendix 5A, Section C Table C-16-3). This similarity in the position of X2 would likely result in a similar survival index and habitat index as measured by salinity for Striped Bass and a similar abundance and habitat index for American Shad. Alternative 5 likely would have a similar potential for adverse effects on lampreys, American Shad, and Hardhead as the Second Basis of Comparison. Overall, the potential for effects on lamprey, Striped Bass, American Shad, and Hardhead would be similar under Alternative 5 and the No Action Alternative.

Stanislaus River/Lower San Joaquin River

Fall-Run Chinook Salmon and Steelhead

Changes in Water Temperature

Monthly average temperatures in the Stanislaus River at Goodwin under Alternative 5 would be similar (less than 0.5°F differences) to the No Action Alternative in most of the months and water years. From August through November, water temperatures under Alternative 5 could be somewhat (0.6°F to 1.6°F) warmer, particularly in drier water years. This pattern in temperature changes under Alternative 5 was also predicted downstream at Orange Blossom Bridge. However, the differences are smaller at the San Joaquin River confluence and water temperatures in April and May could be up to 2.1°F cooler under Alternative 5.

The frequency of exceedance of temperature thresholds for steelhead adult migration in the fall months, steelhead smoltification thresholds in April and May at Knights Ferry, and steelhead rearing in summer and fall months are higher under (by up to 8 percent) under Alternative 5 as compared to the No Action Alternative. Frequency of exceedance of thresholds for steelhead spawning and smoltification at Orange Blossom Bridge in March through May are lower by up to 11 percent under Alternative 5 compared to the No Action Alternative.

While specific water temperature thresholds for fall-run Chinook Salmon in the Stanislaus River are not established, temperatures generally suitable for fall-run Chinook Salmon spawning (56°F) would be exceeded in October and November up to 3 percent more frequently under Alternative 5 compared to the No Action Alternative, in the Stanislaus River at Orange Blossom Bridge. During May and June, the 56°F threshold for fall-run rearing is exceeded less frequently (by up to 10 percent) under Alternative 5 compared to the No Action Alternative.

These changes in temperatures are not reflected in Reclamation’s salmon mortality model results for the fall-run Chinook Salmon in the Stanislaus River. As shown in Appendix 9C, the long-term average egg mortality rate is predicted to be around 8.5 percent, with higher mortality rates (in excess of 16 percent) occurring in critical dry years under Alternative 5. Overall, egg mortality is predicted to be similar under Alternative 5 and the No Action Alternative.

Changes in Delta Hydrodynamics

San Joaquin River-origin fall run Chinook salmon smolts are most abundant in the Delta during the months of April, May and June. San Joaquin River-origin steelhead generally move through the Delta during spring however there is less information on their timing relative to Chinook salmon. Thus, hydrodynamics in the entire January through June period could have the potential to affect juvenile steelhead. Near the confluence of the San Joaquin River and the Mokelumne River, the proportion of positive velocities was slightly higher under Alternative 5 relative to the No Action Alternative in January and February and almost indistinguishable from March through June (Appendix 9K). On Old River upstream and downstream of the facilities, the median proportion of positive velocities was similar under Alternative 5 and the No Action Alternative in all months. On the San Joaquin River downstream of the Head of Old River, the median proportion of positive velocities was similar under Alternative 5 and the No Action Alternative in all months.

Changes in Entrainment at Junctions

As described in Appendix 9L, median entrainment at various junctions is indistinguishable or lower under Alternative 5 compared to the No Action Alternative for fall-run Chinook Salmon.

Summary of Effects on Fall-Run Chinook Salmon and Steelhead

The analysis of temperatures indicates somewhat higher temperatures in some water year types and a higher likelihood of exceedance of suitable temperatures for spawning, and lower likelihood of exceeding suitable temperature for rearing of fall-run Chinook Salmon under Alternative 5 as compared to the No Action

Alternative in the Stanislaus River below Goodwin Dam. The effect of higher temperatures is not reflected in overall mortality of fall-run Chinook Salmon eggs predicted by Reclamation's salmon mortality model for fall-run Chinook Salmon in the Stanislaus River. The frequency of exceedance of temperature thresholds for steelhead smoltification and rearing could be more stressful under Alternative 5 compared to the No Action Alternative. However, the higher flows in April and May and lower temperatures in April and May under Alternative 5 may benefit steelhead spawning.

Given the variability in the results and the inherent uncertainty associated with the resolution of the models, it is concluded that Alternative 5 and the No Action Alternative are likely to have similar effects on fall-run Chinook Salmon and steelhead in the Stanislaus and lower San Joaquin rivers.

White Sturgeon

Evidence of White Sturgeon spawning has been recorded in the San Joaquin River upstream of the confluence with the Stanislaus River. While flows in the San Joaquin River upstream of the Stanislaus River are expected be similar under all alternatives, flow contributions from the Stanislaus River could influence water temperatures in the San Joaquin River where White Sturgeon eggs or larvae may occur during the spring and early summer. The magnitude of influence on water temperature would depend on the proportional flow contribution of the Stanislaus River and the temperatures in both the Stanislaus and San Joaquin rivers. The potential for an effect on White Sturgeon eggs and larvae would be influenced by the proportion of the population occurring in the San Joaquin River. In consideration of this uncertainty, it is not possible to distinguish potential effects on White Sturgeon between alternatives.

Reservoir Fishes

Storage levels in New Melones Reservoir would be similar (within 5 percent) for Alternative 5 as compared to the No Action Alternative (Appendix 5A).

Results of the bass nesting success analysis indicate that for March, the likelihood of Largemouth Bass and Smallmouth Bass nest survival in New Melones being above 40 percent is 100 percent under both Alternative 5 and the No Action Alternative. For April, the likelihood that nest survival of Largemouth Bass and Smallmouth Bass is between 40 and 100 percent is predicted to be reasonably high but is somewhat (about 13 percent) lower under Alternative 5 as compared to the No Action Alternative. For May, the difference between alternatives is less with the likelihood of high nest survival being about 5 percent less under Alternative 5. For June, the likelihood of survival being greater than 40 percent for Largemouth Bass and Smallmouth Bass in New Melones is similar under Alternative 5 and the No Action Alternative. For Spotted Bass, nest survival in March is anticipated to be near 100 percent in every year under both Alternative 5 and the No Action Alternative. The likelihood of Spotted Bass nest survival being greater than 40 percent is about 7 percent less under Alternative 5 than under the No Action Alternative in April, but is still reasonably high (greater than 90 percent). During May, the likelihood of high (>40 percent) Spotted Bass nest survival is about 5 percent lower under Alternative 5 as compared to the No Action Alternative. During June, Spotted Bass nest survival would be greater than 40 percent in every year under Alternative 5 as compared to approximately 98 percent of the years under the No Action Alternative.

Overall, the analysis suggests that conditions under Alternative 5 have the potential to negatively influence black bass nesting success, especially in April and May, by comparison to the No Action Alternative. However, nesting success under Alternative 5 would still exceed 40 percent most of the time under both alternatives. Therefore, it is concluded that there would be no definitive difference in effects on reservoir fish between Alternative 5 and the No Action Alternative.

Other Species

Changes in operations that influence temperature and flow conditions in the Stanislaus River downstream of Goodwin Dam and the San Joaquin River at Vernalis could affect other fishes such as lampreys, Hardhead, and Striped Bass.

Monthly average temperatures in the Stanislaus River at Goodwin under Alternative 5 would be similar (less than 0.5°F differences) to the No Action Alternative in most of the months and water years. From August through November, water temperatures under Alternative 5 could be somewhat (0.6°F to 1.6°F) warmer, particularly in drier water years. This pattern in temperature changes under Alternative 5 was also predicted downstream at Orange Blossom Bridge. However, the differences are smaller at the San Joaquin River confluence and water temperatures in April and May could be up to 2.1°F cooler under Alternative 5.

In general, lamprey species can tolerate higher temperatures than salmonids, up to around 72°F during their entire life history. Because lamprey ammocoetes remain in the river for several years, any substantial flow reductions or temperature increases could result in adverse effects on larval lamprey.

In general, Striped Bass and Hardhead also can tolerate higher temperatures than salmonids. Given the similar flows and generally similar temperatures during their spawning and incubation period, it is likely that the potential to affect Striped Bass and Hardhead in the Stanislaus and San Joaquin rivers would be similar under Alternative 5 and the No Action Alternative.

Given the similarity of the results and the inherent uncertainty associated with the resolution of the models, it is concluded that Alternative 5 and the No Action Alternative are likely to have similar effects on lampreys, Hardhead, and Striped Bass in the Stanislaus and lower San Joaquin rivers. No definitive difference between Alternative 5 and the No Action Alternative could be discerned.

San Francisco Bay Area Region

Killer Whale

As described above for the comparison of Alternative 1 to the No Action Alternative, it is unlikely that the Chinook Salmon prey base of killer whales, supported heavily by hatchery production of fall-run Chinook Salmon, would be appreciably affected by any of the alternatives.

9.4.3.6.1 Alternative 5 Compared to the Second Basis of Comparison

As described in Chapter 3, Description of Alternatives, CVP and SWP operations under Alternative 5 are similar to the No Action Alternative with modified OMR flow criteria and New Melones Reservoir operations. Therefore, the comparison of Alternative 5 to the Second Basis of Comparison would be similar to the comparison of No Action Alternative to Second Basis of Comparison described above in Section 9.4.4.1, No Action Alternative.

Trinity River Region

Coho Salmon, Spring-run Chinook Salmon, Fall-run Chinook Salmon, and Steelhead

Monthly water temperature in the Trinity River at Lewiston Dam under Alternative 5 generally would be similar (less than 0.5°F differences) to the temperatures that would occur under the Second Basis of Comparison (Appendix 6B, Table B-1-6), with the exception of drier years when temperatures under Alternative 5 could be as much as 2.2°F cooler in November and 1.5°F warmer in December. Average monthly water temperatures could be slightly (up to 0.6°F) higher under Alternative 5 during July and August and lower (up to 0.7°F) in September in some water year types. The slightly lower September temperatures under Alternative 5 may result in slightly better conditions than under the Second Basis of Comparison for spring-run Chinook Salmon spawning. Similarly, temperature conditions under Alternative 5 could be slightly better than the Second Basis of Comparison for fall-run Chinook Salmon spawning because of the reduced temperatures in November during critical dry years.

Under Alternative 5, water temperature thresholds for Coho Salmon, fall-run Chinook Salmon, and steelhead would be exceeded slightly more frequently (less than 1 percent), whereas thresholds for spring-run Chinook Salmon would be exceeded less frequently (up to 4 percent) in August in September (Appendix 9N).

These temperature results are not entirely reflected in the egg mortality results for fall-run Chinook Salmon, which indicate similar levels of egg mortality under Alternative 5 compared to the Second Basis of Comparison (Appendix 9C, Table B-5).

The minor changes in water temperatures and mortality suggest that conditions for Coho Salmon, fall-run Chinook Salmon, and steelhead in the Trinity River would be similar under both Alternative 5 and the Second Basis of Comparison. However, the slight reduction in threshold exceedances for spring-run Chinook

Salmon spawning under Alternative 5, although small, could reduce the potential for adverse impacts in the Trinity River under Alternative 5.

In addition, implementation of a Hatchery Management Plan under Alternative 5 could reduce the impacts of hatchery Chinook Salmon on natural Chinook Salmon in the Trinity River and increase the genetic diversity and diversity of run-timing for these stocks relative to the Second Basis of Comparison, but the potential magnitude of these benefits is uncertain. Thus, given these relatively minor changes in temperature and temperature threshold exceedance, the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), and the uncertainty of the hatchery benefits, it is concluded that Alternative 5 and Second Basis of Comparison are likely to have similar effects on Chinook Salmon and steelhead in the Trinity River.

Reservoir Fishes

The analysis of effects associated with changes in operation on reservoir fishes relied on evaluation of changes in available habitat (reservoir storage) and anticipated changes in black bass nesting success.

Black bass species in Trinity Lake would be exposed to minor differences in storage under both Alternative 5 and the Second Basis of Comparison, and these relatively small differences would have negligible effect on nest survival. The nest survival under Alternative 5 would be generally similar to Second Basis of Comparison for Largemouth Bass, Smallmouth Bass, and Spotted Bass (Appendix 9F). These negligible differences in nest survival suggest that conditions for reservoir species in Trinity Lake would be similar under Alternative 5 and the Second Basis of Comparison.

Other Species

The minor differences in average monthly water temperatures described above for salmonids apply to Pacific Lamprey, Eulachon, and other aquatic species in the Trinity River. These minor differences suggest that conditions for aquatic species in the Trinity River and Klamath River downstream of the confluence generally would be similar under Alternative 5 and the Second Basis of Comparison.

Sacramento River System

Winter-run Chinook Salmon

Changes in operations that influence temperature and flow conditions in the Sacramento River downstream of Keswick Dam could affect winter-run Chinook Salmon. The following describes those changes and their potential effects.

Changes in Water Temperature

Monthly water temperature in the Sacramento River at Keswick Dam under Alternative 5 and the Second Basis of Comparison generally would be similar (differences less than 0.5°F). Average monthly water temperatures in September under Alternative 5 would be lower (up to 0.9°F) in wetter years and higher (up to 1.2°F) in drier years (Appendix 6B). Similarly, water temperatures in October of critical years could be 0.9°F warmer under Alternative 5. A similar temperature pattern generally would be exhibited downstream at Ball’s Ferry, Jelly’s Ferry, and Bend Bridge, with average monthly temperature differences in September increasing (up to 2.8°F cooler at Bend Bridge) in September during the wetter years and up to 0.8°F warmer in critical years (Appendix 6B).

Changes in Exceedances of Water Temperature Thresholds

With the exception of April, average monthly water temperatures under both Alternative 5 and Second Basis of Comparison would show exceedances of the water temperature threshold of 56°F established in the Sacramento River at Ball's Ferry for winter-run Chinook Salmon spawning and egg incubation in every month, with exceedances under both as high as about 41 percent and 54 percent, respectively, in some months (Appendix 9N). Under Alternative 5, the temperature threshold generally would be exceeded more frequently than under the Second Basis of Comparison (by about 1 percent to 3 percent) in the April through August period, with the temperature threshold in September exceeded about 11 percent less frequently under Alternative 5 than under the Second Basis of Comparison. Farther downstream at Bend Bridge, the frequency of exceedances would increase, with exceedances under both Alternative 5 and the Second Basis of Comparison as high as about 90 percent in some months. Under Alternative 5, temperature exceedances generally would be more frequent (by up to 10 percent) than under the Second Basis of Comparison, with the exception of September, when exceedances under Alternative 5 would be about 30 percent less frequent under Alternative 5.

Changes in Egg Mortality

The temperatures described above for the Sacramento River below Keswick Dam are reflected in the analysis of egg mortality using the Reclamation Salmon Survival Model (Appendix 9C). For winter-run Chinook Salmon in the Sacramento River, the long-term average egg mortality rate is predicted to be relatively low (around 5 percent), with higher mortality rates (exceeding 20 percent) occurring in critical dry years under Alternative 5. Overall, egg mortality would be similar under Alternative 5and the Second Basis of Comparison (Appendix 9C, Table B-4).

Changes in Weighted Usable Area

As an indicator of the amount of suitable spawning habitat for winter-run Chinook Salmon between Keswick Dam and Battle Creek, modeling results indicate that, in general, there would be similar amounts of spawning habitat available from May through September under Alternative 5 as compared to the Second Basis of Comparison (Appendix 9E, Table C-17-6). Modeling results indicate that, in general, there would be similar amounts of suitable fry rearing habitat available from June through October under Alternative 5 and the Second Basis of Comparison (Appendix 9E, Table C-18-6). Similar to the results for fry rearing WUA, modeling results indicate that there would be similar amounts of suitable juvenile rearing habitat available during the juvenile rearing period under Alternative 5 and the Second Basis of Comparison (Appendix 9E, Table C-19-6).

Changes in SALMOD Output

SALMOD results indicate that potential juvenile production would be the same under Alternative 5 and the Second Basis of Comparison (Appendix 9D, Table B-4-26).

Changes in Delta Passage Model Output

The Delta Passage Model predicted similar estimates of annual Delta survival across the 81 water year time period for winter-run Chinook Salmon between Alternative 5 and the Second Basis of Comparison Alternative (Appendix 9J). Median Delta survival was 0.350 for Alternative 5 and 0.352 for the Second Basis of Comparison Alternative. Overall, there would be little change in through-Delta survival for emigrating juvenile winter-run Chinook Salmon under Alternative 5 as compared to the Second Basis of Comparison.

Changes in Delta Hydrodynamics

Winter run smolts are most abundant in the Delta during the months of January February and March. On the Sacramento River near the confluence of Georgiana Slough, the median proportion of positive velocities under Alternative 5 was indistinguishable from the Second Basis of Comparison in January, February, and March (Appendix 9K). On the San Joaquin River near the Mokelumne River confluence, the median proportion of positive velocities was slightly greater under Alternative 5 relative to Second Basis of Comparison in January and February and similar in March. In Old River downstream of the facilities, the median proportion of positive velocities was substantially higher under Alternative 5 during January and moderately higher in February. Values in March were almost indistinguishable between scenarios. On Old River upstream of the facilities, the median proportion of positive velocities was moderately lower in January and February and slightly lower in March under Alternative 5 relative to Second Basis of Comparison. On the San Joaquin River downstream of Head of Old River, the median proportion of positive velocities was similar for both scenarios in January, February and March.

Changes in Junction Entrainment

At the junction of Georgiana Slough and the Sacramento River, median entrainment under Alternative 5 and the Second Basis of Comparison was essentially indistinguishable in January, February and March (Appendix 9L). Entrainment at the Head of Old River junction was similar to slightly lower under Alternative 5 relative to Second Basis of Comparison during the period of winter run Chinook Salmon migration through the Delta (January, February, and March). For the Turner Cut junction, median entrainment under Alternative 5 was slightly lower in January and February relative to Second Basis of Comparison. In March, the difference in entrainment between scenarios was similar. At the Columbia Cut, Middle River and Old River junctions, patterns in entrainment between Alternative 5 and Second Basis of Comparison were similar. At these junctions, median entrainment was slightly to moderately lower under Alternative 5 during January and February and values were more similar in March.

Changes in Salvage

Salvage of winter-run Chinook salmon is predicted to be substantially lower under Alternative 5 relative to the Second Basis of Comparison in January and February (Appendix 9M). In March, predicted salvage was only moderately lower under Alternative 5 relative to Second Basis of Comparison.

Changes in Oncorhynchus Bayesian Analysis Output

Escapement of winter-run Chinook Salmon and Delta survival was modeled by the Oncorhynchus Bayesian Analysis (OBAN) model for winter-run Chinook salmon. Escapement was generally higher under Alternative 5 as compared to the Second Basis alternative (Appendix 9I). The median abundance under Alternative 5 was higher the Second Basis of Comparison. Median delta survival was approximately 15 percent higher under Alternative 5 as compared to the Second Basis of Comparison.

Changes in Interactive Object-Oriented Simulation Output

The IOS model predicted similar adult escapement trajectories for Winter-Run Chinook salmon between Alternative 5 and the Second Basis of Comparison Alternative across the 81 water years (Appendix 9H). Alternative 5 median adult escapement was 3,545 and Second Basis of Comparison Alternative median escapement was 4,042).

Similar to adult escapement, the IOS model predicted similar egg survival for Winter-Run Chinook salmon between Alternative 5 and the Second Basis of Comparison Alternative across the 81 water years (Appendix 9H). Median egg survival was 0.989 for Alternative 5 and 0.987 for the Second Basis of Comparison Alternative).

Summary of Effects on Winter-Run Chinook Salmon

The analysis of temperatures indicates somewhat higher temperatures and greater likelihood of exceedance of thresholds under Alternative 5 as compared to the Second Basis of Comparison. This is not reflected in the similar survival of winter-run Chinook Salmon eggs predicted by Reclamation’s salmon mortality model. Flow changes under Alternative 5 would have small effects on the availability of spawning and rearing habitat for winter-run Chinook Salmon as indicated by the WUA analysis and the decrease in flow (habitat)-related mortality predicted by SALMOD under Alternative 5. Through Delta survival of juvenile winter-run Chinook Salmon would be the same under both Alternative 5 and Second Basis of Comparison as indicated by the DPM results; the OBAN results suggest that Delta survival could be higher under Alternative 5. Entrainment may also be reduced under Alternative 5 as indicated by the salvage analysis based on OMR flows. Median adult escapement to the Sacramento River could be reduced slightly under Alternative 5 as indicated by the IOS model results which incorporate temperature, flow, and mortality effects on each life stage over the entire life cycle of winter-run Chinook Salmon. However, the OBAN model results indicate an increase in escapement over a more limited time period (1971 to 2002).

The model results suggest that effects on winter-run Chinook Salmon would be similar under both Alternative 5 and Second Basis of Comparison, with a small likelihood that winter-run Chinook Salmon escapement would be higher under the Alternative 5. Positive effects, however, likely would be greater because of the potential benefits of providing fish passage under Alternative 5 intended to address the limited availability of suitable habitat for winter-run Chinook Salmon in the Sacramento River reaches downstream of Keswick Dam. This potential beneficial effect and its magnitude would depend on the success of the fish passage program. In addition, benefits to winter-run Chinook Salmon may accrue under Alternative 5 as a result actions intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities to improve the overall salvage survival of listed salmonids, including winter-run Chinook Salmon.

Overall, the quantitative results from the numerical models suggest that operation under Alternative 5 would be less likely to result in adverse effects on winter-run Chinook Salmon than would the Second Basis of Comparison. In consideration of the potentially beneficial effects resulting from actions under the Alternative 5 that are not included in the numerical models (see Appendix 5A, Section B), however, Alternative 5 has a much greater potential to address the long-term sustainability of winter-run Chinook Salmon than does the Second Basis of Comparison. Alternative 5 includes provisions for fish passage upstream of Shasta Dam to address long-term temperature increases associated with climate change; the Second Basis of Comparison does not. Even though the success of fish passage is uncertain, it is concluded that the potential for adverse effects on winter-run Chinook Salmon under Alternative 5 would clearly be less than those under the Second Basis of Comparison, principally because the Second Basis of Comparison does not include a strategy to address water temperatures critical to winter-run Chinook Salmon sustainability over the long term with climate change by 2030.

Spring-run Chinook Salmon

Changes in operations that influence temperature and flow conditions in the Sacramento River downstream of Keswick Dam, Clear Creek downstream of Whiskeytown Dam, and Feather River downstream of Oroville Dam could affect spring-run Chinook Salmon. The following describes those changes and their potential effects.

Changes in Water Temperature

Changes in water temperature that could affect spring-run Chinook Salmon could occur in the Sacramento River, Clear Creek, and Feather River. The following describes temperature conditions in those water bodies.

Sacramento River

Monthly water temperature in the Sacramento River at Keswick Dam under Alternative 5 and the Second Basis of Comparison generally would be similar (differences less than 0.5°F). Average monthly water temperatures in September under Alternative 5 would be lower (up to 0.9°F) in wetter years and higher (up to 1.2°F) in drier years. Similarly, water temperatures in October of critical years could be 0.9°F warmer under Alternative 5. A similar temperature pattern generally would be exhibited downstream at Ball’s Ferry, Jelly’s Ferry, Bend Bridge and Red Bluff, with average monthly temperature differences in September progressively increasing (up to 3.2°F cooler at Red Bluff) during the wetter years (Appendix 6B, Table B-9-6).

Clear Creek

Average monthly water temperatures in Clear Creek at Igo under Alternative relative to the Second Basis of Comparison are generally predicted to be similar (less than 0.5°F differences) (Appendix 6B, Table B-3-6). Average monthly water temperatures during May under Alternative 5 would be up to 0.8°F lower than under the Second Basis of Comparison in all but critical water years. The lower water temperatures in May associated with Alternative 5 reflect the effects of additional water discharged from Whiskeytown Dam to meet the spring attraction flow requirements to promote attraction of spring-run Chinook Salmon into the creek. While the reduction in May water temperatures indicated by the modeling could improve thermal conditions for spring-run Chinook Salmon, the duration of the two pulse flows may not be of sufficient duration (3 days each) to provide temperature benefits.

Feather River

Long-term average monthly water temperature in the Feather River at the low flow channel under Alternative 5 relative to the Second Basis of Comparison generally would be similar (less than 0.5°F differences). Water temperatures could be up to 1.5°F warmer in November and December of some water year types and up to 1.2°F cooler in September of wetter years (Appendix 6B, Table B-20-6) under Alternative 5. Although temperatures in the river would become progressively higher in the downstream direction, the differences between Alternative 5 and Second Basis of Comparison exhibit a similar pattern at the downstream locations (Robinson Riffle and Gridley Bridge), with water temperature differences under Alternative 5 generally increasing in most water year types relative to the Second Basis of Comparison at the confluence with Sacramento River (Appendix 6B, Table B-23-6). Water temperatures under Alternative 5 could be somewhat (0.8°F to 1.6°F) cooler on average and up to 3.9°F cooler (September) at the confluence with Sacramento River from July to September in wetter years.

Changes in Exceedances of Water Temperature Thresholds

Changes in water temperature could result in the exceedance of established water temperature thresholds for spring-run Chinook Salmon in the Sacramento River, Clear Creek, and Feather River. The following describes the extent of those exceedance for each of those water bodies.

Sacramento River

Average monthly water temperatures under both Alternative 5 and Second Basis of Comparison would show exceedances of the water temperature threshold of 56°F established in the Sacramento River at Red Bluff for spring-run Chinook Salmon (egg incubation) in October, November, and again in April. The exceedances would occur at the greatest frequency in October, with 80 percent and 79 percent for Alternative 5 and Second Basis of Comparison, respectively. Temperature thresholds would be exceeded less frequently in November (7 percent) and not exceeded at all during December through March. As water temperatures warm in the spring, the thresholds would be exceeded in April by 14 percent and 13 percent under Alternative 5 and Second Basis of Comparison. In the warmer months when exceedances occur (October, November, and April), temperature thresholds generally would be exceeded more frequently (by up to 2 percent in October) under Alternative 5 than under the Second Basis of Comparison (Appendix 9N, Table 9N.B.1).

Clear Creek

Average monthly water temperatures under both Alternative 5 and Second Basis of Comparison would not exceed the water temperature threshold of 60°F established in Clear Creek at Igo for spring-run Chinook Salmon pre-spawning and rearing in June through August. However, Alternative 5 and Second Basis of Comparison would exceed the water temperature threshold of 56°F established for spawning in September and October about 10 percent to 15 percent of the time. The differences between Alternative 5 and Second Basis of Comparison are small, with Alternative 5 exceeding thresholds about 1 percent more frequently than under the Second Basis of Comparison in September and about 2 percent more frequently in October (Appendix 9N).

Feather River

Average monthly water temperatures under both Alternative 5 and Second Basis of Comparison would exceed the water temperature threshold of 56°F established in the Feather River at Robinson Riffle for spring-run Chinook Salmon egg incubation and rearing (Appendix 9N) during some months, particularly in October and November, and March and April, when temperature thresholds could be exceeded frequently. The frequency of exceedance was highest (about 98 percent) in October, a month in which average monthly water could get as high as about 68°F. However, water temperatures under Alternative 5 would exceed temperature thresholds less than 2 percent more frequently than the Second Basis of Comparison in October, November, and December, and about 1 percent less frequently in March. The established water temperature threshold of 63°F for rearing during May through August would be exceeded often under both Alternative 5 and Second Basis of Comparison in May (57 percent and 51 percent, respectively) and June (97 percent for both), but not at all in July and August.

Changes in Egg Mortality

These temperature differences described above are reflected in the analysis of egg mortality using the Reclamation salmon mortality model (Appendix 9C). For spring-run Chinook Salmon in the Sacramento River, the long-term average egg mortality rate is predicted to be relatively high (exceeding 20 percent), with high mortality rates (exceeding 80 percent) occurring in critical dry years. In critical dry years the average egg mortality rate would be 13.1 percent greater under Alternative 5 than under the Second Basis of Comparison (Appendix 9C,

Table B-3). Overall, egg mortality under Alternative 5 and the Second Basis of Comparison would be similar, except in critical dry water years.

Changes in Weighted Usable Area

Weighted usable area curves are available for spring-run Chinook Salmon in Clear Creek. As described above, flows in Clear Creek below Whiskeytown Dam are not anticipated to differ under Alternative 5 relative to the Second Basis of Comparison except in May due to the release of spring attraction flows in accordance with the 2009 NMFS BO. Therefore, there would be no change in the amount of potentially suitable spawning and rearing habitat for spring-run Chinook Salmon (as indexed by WUA) available under Alternative 5 as compared to the Second Basis of Comparison.

Changes in SALMOD Output

SALMOD results indicate that potential spring-run juvenile production would be similar under Alternative 5 and the Second Basis of Comparison, except in critical dry years when production could be 14 percent lower under Alternative 5 than under the Second Basis of Comparison (Appendix 9D).

Changes in Delta Passage Model Output

The Delta Passage Model predicted similar estimates of annual Delta survival across the 81 water year time period for spring-run between Alternative 5 and the Second Basis of Comparison (Appendix 9J). Median Delta survival was 0.296 for Alternative 5 and 0.286 for the Second Basis of Comparison. Overall, there would be little change in through-Delta survival by emigrating juvenile spring-run Chinook Salmon under Alternative 5 as compared to the Second Basis of Comparison.

Changes in Delta Hydrodynamics

Spring run Chinook salmon are most abundant in the Delta from March through May. Near the junction of Georgiana Slough, the median proportion of time that velocity was positive was similar in March and April and slightly lower in May under Alternative 5 relative to the Second Basis of Comparison (Appendix 9K). Near the confluence of the San Joaquin River and the Mokelumne River, the median proportion of positive velocities was similar in March and slightly to moderately higher under Alternative 5 relative to the Second Basis of Comparison in April and May. In the San Joaquin River downstream of the Head of Old River the median proportion of positive velocities was slightly to moderately higher under Alternative 5 relative to Second Basis of Comparison in April and May, respectively, whereas there was little difference between these scenarios in March. In Old River upstream of the facilities the median proportion of positive velocities was slightly higher in April and May under Alternative 5 relative to Second Basis of Comparison and slightly lower in March. In Old River downstream of the facilities, the median proportion of positive velocities was substantially higher under Alternative 5 relative to Second Basis of Comparison in April and May and more similar in March.

Changes in Junction Entrainment

At the junction of Georgiana Slough and the Sacramento River, median entrainment under Alternative 5 was slightly lower than under the Second Basis of Comparison in April and May but essentially indistinguishable in March (Appendix 9L). Median entrainment at the Head of Old River junction was substantially higher under Alternative 5 relative to Second Basis of Comparison during the months of April and May and similar in March. For the Turner Cut junction, median entrainment under Alternative 5 was moderately lower in April and May relative to Second Basis of Comparison and more similar in March. At the Columbia Cut, Middle River and Old River junctions, entrainment under Alternative 5 was slightly lower than Second Basis of Comparison in March and became moderately to substantially lower in April and May.

Changes in Salvage

Salvage of spring run Chinook salmon was predicted to be substantially lower under Alternative 5 relative the Second Basis of Comparison during April and May and only slightly lower in the month of March (Appendix 9M).

Summary of Effects on Spring-Run Chinook Salmon

The multiple model and analysis outputs described above characterize the anticipated conditions for spring-run Chinook Salmon and their response to change under Alternative 5 as compared to the Second Basis of Comparison. For the purpose of analyzing effects on spring-run Chinook Salmon in the Sacramento River, greater reliance was placed on the outputs from the SALMOD model because it integrates the available information on temperature and flows to produce estimates of mortality for each life stage and an overall, integrated estimate of potential spring-run Chinook Salmon juvenile production. The output from SALMOD indicated that spring-run Chinook Salmon production in the Sacramento River would be similar under Alternative 5 and the Second Basis of Comparison, except in critical dry years. The analyses attempting to assess the effects on routing, entrainment, and salvage of juvenile salmonids in the Delta suggest that salvage (as an indicator of potential losses of juvenile salmon at the export facilities) of Sacramento River-origin Chinook Salmon is predicted to be lower under Alternative 5 relative to the Second Basis of Comparison in every month.

In Clear Creek and the Feather River, the analysis of the effects of Alternative 5 and Second Basis of Comparison for spring-run Chinook Salmon relied on water temperature output for Clear Creek at Igo, and in the Feather River low flow channel and downstream of the Thermalito complex. The analysis of temperatures indicates somewhat higher temperatures and greater likelihood of exceedance of thresholds under Alternative 5 as compared to the Second Basis of Comparison in the Feather River. There would be little change in flows or temperatures in Clear Creek under Alternative 5 relative to the Second Basis of Comparison. The effect of slightly increased temperatures is not reflected in the similar overall survival of spring-run Chinook Salmon eggs predicted by Reclamation’s salmon mortality model for spring-run in the Sacramento River. In drier years, the likelihood of adverse temperature effects would be increased under Alternative 5 as compared to the Second Basis of Comparison.

Flow changes under Alternative 5 would likely have small effects due to changes in the availability of spawning and rearing habitat for spring-run Chinook Salmon in the Sacramento River as indicated by the decrease in flow (habitat)-related mortality predicted by SALMOD under Alternative 5. Through Delta survival of juvenile spring-run Chinook Salmon would be the same under both Alternative 5 and Second Basis of Comparison as indicated by the DPM results and entrainment could be reduced as indicated by the salvage analysis.

The numerical model results suggest that, overall, Alternative 5 likely would have similar or somewhat greater adverse effects on the spring-run Chinook Salmon population in the Sacramento River watershed as compared to the Second Basis of Comparison, particularly in drier water year types. This potential distinction between the two scenarios, however, may be offset by the benefits of implementation of fish passage under Alternative 5 intended to address the limited availability of suitable habitat for spring-run Chinook Salmon in the Sacramento River reaches downstream of Keswick Dam. This beneficial effect and its magnitude would depend on the success of the fish passage program. In addition, spring-run Chinook Salmon may benefit from actions under Alternative 5 intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities to improve the overall salvage survival of listed salmonids, including spring-run Chinook Salmon.

Thus, it is concluded that the potential for adverse effects on spring-run Chinook Salmon under Alternative 5 suggested by the results of the numerical models would likely be offset by the potential benefits of the actions that are not included in the numerical models, principally because the Second Basis of Comparison does not include a strategy to address water temperatures critical to spring-run Chinook Salmon sustainability over the long term with climate change by 2030. On balance and over the long term, the adverse effects on spring-run Chinook Salmon under Alternative 5 would be less than those under the Second Basis of Comparison.

Fall-Run Chinook Salmon

Changes in operations that influence temperature and flow conditions in the Sacramento River downstream of Keswick Dam, Clear Creek downstream of Whiskeytown Dam, Feather River downstream of Oroville Dam and American River below Nimbus could affect fall-run Chinook Salmon. The following describes those changes and their potential effects.

Changes in Water Temperature

Changes in water temperature could affect fall-run Chinook Salmon in the Sacramento, Feather, and American rivers, and Clear Creek. The following describes temperature conditions in those water bodies.

Sacramento River

Monthly water temperature in the Sacramento River at Keswick Dam under Alternative 5 and the Second Basis of Comparison generally would be similar (differences less than 0.5°F). Average monthly water temperatures in September under Alternative 5 would be lower (up to 0.9°F) in wetter years and higher (up to 1.2°F) in drier years. Similarly, water temperatures in October of critical years could be 0.9°F warmer under Alternative 5. A similar pattern in temperatures generally would be exhibited at downstream locations along the Sacramento River (i.e., Ball's Ferry Jelly's Ferry, Bend Bridge, Red Bluff, Hamilton City, and Knights Landing), with differences in average monthly temperatures at Knights Landing progressively increasing (up to 1.0°F warmer) in June and up to up to 4.6°F cooler in September of wetter years under Alternative 5 relative to the Second Basis of Comparison.

Clear Creek

Average monthly water temperatures in Clear Creek at Igo under Alternative relative to the Second Basis of Comparison are generally predicted to be similar (less than 0.5°F differences) (Appendix 6B, Table B-3-6). Average monthly water temperatures during May under Alternative 5 would be up to 0.8°F lower than under the Second Basis of Comparison in all but critical water years. The lower water temperatures in May associated with Alternative 5 reflect the effects of additional water discharged from Whiskeytown Dam to meet the spring attraction flow requirements to promote attraction of spring-run Chinook Salmon into the creek. While the reduction in May water temperatures indicated by the modeling could improve thermal conditions for fall-run Chinook Salmon, the duration of the two pulse flows may not be of sufficient duration (3 days each) to provide temperature benefits.

Feather River

Long-term average monthly water temperature in the Feather River at the low flow channel under Alternative 5 relative to the Second Basis of Comparison generally would be similar (less than 0.5°F differences). Water temperatures could be up to 1.5°F warmer in November and December of some water year types and up to 1.2°F cooler in September of wetter years. Although temperatures in the river would become progressively higher in the downstream direction, the differences between Alternative 5 and Second Basis of Comparison exhibit a similar pattern at the downstream locations (Robinson Riffle and Gridley Bridge), with water temperature differences under Alternative 5 generally increasing in most water year types relative to the Second Basis of Comparison at the confluence with Sacramento River (Appendix 6B, Table B-23-6). Water temperatures under Alternative 5 could be somewhat (0.8°F to 1.6°F) cooler on average and up to 3.9°F cooler (September) at the confluence with Sacramento River from July to September in wetter years.

American River

Average monthly water temperatures in the American River at Nimbus Dam under Alternative 5 generally would be similar (differences less than 0.5°F) to the Second Basis of Comparison, with the exception of during June and August of below normal water years, when temperatures under Alternative 5 could be as much as 0.9°F higher. This pattern generally would persist downstream to Watt Avenue and the mouth, although temperatures under Alternative 5 would be up to 1.6°F and 2.1°F higher, respectively, than under the Second Basis of Comparison in June. In addition, average monthly water temperatures at the mouth under Alternative 5 generally would be lower than under the Second Basis of Comparison in September, especially in wetter water year types when water temperatures under Alternative 5 could be up to 1.7°F cooler.

Changes in Exceedances of Water Temperature Thresholds

Changes in water temperature could result in the exceedance of water temperatures that are protective of fall-run Chinook Salmon in the Sacramento River, Clear Creek, Feather River, and American River. The following describes the extent of those exceedances for each of those water bodies.

Sacramento River

Average monthly water temperatures under both Alternative 5 and Second Basis of Comparison would exceed the water temperature threshold of 56°F established in the Sacramento River at Red Bluff for fall-run Chinook Salmon spawning and egg incubation (Table temperature targets) during some months, particularly in October, November, and April, when temperature thresholds would be exceeded. The frequency of exceedance would be greatest in October, a month in which average monthly water temperature could get as high as about 64°F. In October, average monthly water temperatures under Alternative 5 and Second Basis of Comparison would exceed the threshold 82 percent and 79 percent of the time, respectively. The differences in the frequency of exceedances between Alternative 5 and Second Basis of Comparison would be small. Water temperatures under Alternative 5 would exceed temperature thresholds about 2 percent more frequently than under the Second Basis of Comparison in October, 1 percent less frequently in November, and 1 percent more frequently in April.

Clear Creek

Fall-run Chinook Salmon spawning in lower Clear Creek typically occurs during October through December (USFWS 2015). Average monthly water temperatures at Igo during this period generally would be below 56°F, except in October. Under Alternative 5, the 56°F threshold would be exceeded in October about 12 percent of the time as compared to 10 percent under the Second Basis of Comparison. At the confluence with the Sacramento River, average monthly water temperatures in October would be warmer, with 56°F exceeded nearly 20 percent of the time under Alternative 5 and somewhat (about 8 percent) less frequently under the Second Basis of Comparison. During November and December, average monthly water temperatures generally would remain below 56°F at both locations.

For fall-run Chinook Salmon rearing (January through September), the exceedances described previously for spring-run Chinook Salmon would apply, with the average monthly temperatures remaining below the 60°F threshold except in September when temperatures could increase to over 60°F. During September, water temperatures under Alternative 5 would exceed 56°F about 3 percent more frequently than under the Second Basis of Comparison. Downstream at the mouth, the average monthly temperatures would exceed 56°F more frequently, especially in July and August, when it always would be exceeded and average monthly temperatures would approach 64°F under both scenarios in September.

Under Alternative 5, temperature conditions at Igo would be slightly warmer than under the Second Basis of Comparison. Average monthly water temperatures likely mask daily temperatures excursions that could exceed important thresholds. Therefore, while the differences in threshold exceedance are relatively minor, the likelihood of adverse effects on fall-run Chinook Salmon in Clear Creek under Alternative 5 would likely be greater than under the Second Basis of Comparison.

Feather River

Average monthly water temperatures under both Alternative 5 and Second Basis of Comparison would exceed the water temperature threshold of 56°F established in the Feather River at Gridley Bridge for fall-run Chinook Salmon spawning and egg incubation during some months, particularly in October, November, March, and April, when temperature thresholds would be exceeded frequently (Appendix 9N). The frequency of exceedance would be greatest in October, when average monthly temperatures under both Alternative 5 and Second Basis of Comparison would be above the threshold in nearly every year. The magnitude of the exceedances would be high as well, with average monthly temperatures in October reaching about 68°F. Similarly, the threshold would be exceeded under both Alternative 5 and the Second Basis of Comparison about 85 percent of the time in April. The differences in threshold exceedance between Alternative 5 and Second Basis of Comparison, would be small, with water temperatures under Alternative 5 generally exceeding temperature thresholds about 1-2 percent more frequently than the Second Basis of Comparison during the October through April period. However, average monthly water temperatures likely mask daily temperatures excursions that could exceed important thresholds. Therefore, while the differences in threshold exceedance are relatively minor, the likelihood of adverse effects on fall-run Chinook Salmon in the Feather River under Alternative 5 would likely be greater than under the Second Basis of Comparison.

Changes in Egg Mortality

Water temperatures influence the viability of incubating fall-run Chinook Salmon eggs. The following describes the differences in egg mortality for the Sacramento, Feather, and American rivers.

Sacramento River

For fall-run Chinook Salmon in the Sacramento River, the long-term average egg mortality rate is predicted to be around 17 percent, with higher mortality rates (in excess of 35 percent) occurring in critical dry years under Alternative 5. Overall, egg mortality would be similar under Alternative 5 and the Second Basis of Comparison (Appendix 9C, Table B-1).

Feather River

For fall-run Chinook Salmon in the Feather River, the long-term average egg mortality rate is predicted to be relatively low (around 7 percent), with higher mortality rates (around 14 percent) occurring in critical dry years under Alternative 5. Overall, egg mortality would be similar under Alternative 5 and the Second Basis of Comparison (Appendix 9C, Table B-7).

American River

For fall-run Chinook Salmon in the American River, the long-term average egg mortality rate is predicted to range from approximately 23 to 25 percent in all water year types under Alternative 5. Overall, egg mortality would be similar under Alternative 5 and the Second Basis of Comparison (Appendix 9C, Table B-6).

Changes in Weighted Usable Area

Weighted usable area, which is influenced by flow, is a measure of habitat suitability. The following describes changes in WUA for fall-run Chinook Salmon in the Sacramento, Feather, and American rivers and Clear Creek.

Sacramento River

As an indicator of the amount of suitable spawning habitat for fall-run Chinook Salmon between Keswick Dam and Battle Creek, modeling results indicate that, in general, there would be lesser amounts of spawning habitat available in September and November under Alternative 5 as compared to the Second Basis of Comparison (Appendix 9E, Table C-11-6). The decrease in long-term average spawning WUA during September (prior to the peak spawning period) would be relatively large (more than 20 percent), with a smaller decrease in November (around 6 percent). The latter month is during the peak spawning period for fall-run Chinook Salmon. Results for the reach from Battle Creek to Deer Creek show the same pattern for changes in WUA for spawning fall-run Chinook Salmon between Alternative 5 and the Second Basis of Comparison (Appendix 9E, Table C-10-6). Overall, spawning habitat availability would be slightly lower under Alternative 5 relative to the Second Basis of Comparison.

Modeling results indicate that, in general, there would be similar amounts of suitable fry rearing habitat available from December to March under Alternative 5 and the Second Basis of Comparison (Appendix 9E, Table C-12-6). Similar to the results for fry rearing WUA, modeling results indicate that, there would be similar amounts of suitable juvenile rearing habitat available during the juvenile rearing period under Alternative 5 and the Second Basis of Comparison (Appendix 9E, Table C-13-6).

Clear Creek

As described above, flows in Clear Creek below Whiskeytown Dam are not anticipated to differ under Alternative 5 relative to the Second Basis of Comparison except in May due to the release of spring attraction flows in accordance with the 2009 NMFS BO. Therefore, there would be no change in the amount of potentially suitable spawning and rearing habitat for fall-run Chinook Salmon (as indexed by WUA) available under Alternative 5 as compared to the Second Basis of Comparison.

Feather River

As described above, Flows in the low flow channel of the Feather River are not anticipated to differ under Alternative 5 relative to the Second Basis of Comparison. Therefore, there would be no change in the amount of potentially suitable spawning habitat for fall-run Chinook Salmon (as indexed by WUA) available under Alternative 5 as compared to the Second Basis of Comparison. The majority of spawning activity by fall-run Chinook Salmon in the Feather River occurs in this reach with a lesser amount of spawning occurring downstream of the Thermalito Complex.

Modeling results indicate that, in general, there would be a lesser amount of spawning habitat available in September (20 percent less) and greater amounts of incubation habitat available in February (6 percent more) under Alternative 5 as compared to the Second Basis of Comparison; fall-run spawning WUA may be slightly (around 5 percent) increased in October (the peak spawning month) for fall-run Chinook Salmon in this reach (Appendix 9E, Table C-24-6). The decrease in long-term average spawning WUA during September would occur prior to the peak spawning period. Overall, spawning and incubation habitat availability would be similar under Alternative 5 relative to the Second Basis of Comparison.

American River

Modeling results indicate that, in general, there would be similar amounts of spawning habitat available for fall-run Chinook Salmon in the American River from October through December under Alternative 5 and the Second Basis of Comparison (Appendix 9E, Table C-25-6).

Changes in SALMOD Output

SALMOD results indicate that potential fall-run juvenile production would be similar under Alternative 5 and the Second Basis of Comparison, except in critical dry years when production could be 7 percent lower under Alternative 5 than under the Second Basis of Comparison (Appendix 9D, Table B-1-26).

Changes in Delta Passage Model Output

The Delta Passage Model predicted similar estimates of annual Delta survival across the 81 water year time period for Fall-run between Alternative 5 and the Second Basis of Comparison Alternative (Appendix 9J). Median Delta survival was 0.248 for Alternative 5 and 0.245 for the Second Basis of Comparison. Overall, there would be little change in through-Delta survival by emigrating juvenile fall-run Chinook Salmon under Alternative 5 as compared to the Second Basis of Comparison.

Changes in Delta Hydrodynamics

Fall run Chinook salmon smolts are most abundant in the Delta during the months of April, May and June. At the junction of Georgiana Slough and the Sacramento River, the median proportion of positive velocities was slightly lower under Alternative 5 relative to the Second Basis of Comparison in May and June (Appendix 9K). The median proportion of positive velocities for Alternative 5 was similar in April. Near the confluence of the San Joaquin River and the Mokelumne River, the median proportion of positive velocities was slightly to moderately higher under Alternative 5 relative to Second Basis of Comparison in April and May, respectively, whereas values in June were similar. On Old River downstream of the facilities, the median proportion of positive velocities was substantially higher in April and May and slightly higher in June under Alternative 5 relative to Second Basis of Comparison. In Old River upstream of the facilities, the median proportion of positive velocities was slightly higher under Alternative 5 April and May and slightly lower in June. On the San Joaquin River downstream of the Head of Old River, the median proportion of positive velocities was slightly to moderately lower under Alternative 5 relative to Second Basis of Comparison in April and May, respectively, and similar in June.

Changes in Junction Entrainment

At the junction of Georgiana Slough and the Sacramento River, median entrainment under Alternative 5 was slightly lower than the Second Basis of Comparison in June but essentially indistinguishable in all other months (Appendix 9L). Median entrainment at the Head of Old River junction was considerably higher under Alternative 5 relative to Second Basis of Comparison during the months of April and May and slightly lower in June. For the Turner Cut junction, median entrainment under Alternative 5 was moderately lower in April and May relative to Second Basis of Comparison and slightly lower in June. At the Columbia Cut junction, median entrainment under Alternative 5 was slightly lower in June relative to the Second Basis of Comparison. Median entrainment was substantially lower under Alternative 5 relative to Second Basis of Comparison in April and May. A similar pattern of entrainment under Alternative 5 relative to Second Basis of Comparison was observed at the Middle River and Old River junctions.

Changes in Salvage

Salvage of Sacramento River-origin fall run was predicted to be substantially lower under Alternative 5 relative to the Second Basis of Comparison in April and May (Appendix 9M). During the month of June, salvage was moderately lower under Alternative 5.

Summary of Effects on Fall-Run Chinook Salmon

The multiple model and analysis outputs described above characterize the anticipated conditions for fall-run Chinook Salmon and their response to change under Alternative 5 as compared to the Second Basis of Comparison. For the purpose of analyzing effects on fall-run Chinook Salmon in the Sacramento River, greater reliance was placed on the outputs from the SALMOD model because it integrates the available information on water temperature and flows to produce estimates of mortality for each life stage and an overall, integrated estimate of potential fall-run Chinook Salmon juvenile production. The output from SALMOD indicated that fall-run Chinook Salmon production would be similar under Alternative 5 and the Second Basis of Comparison, except in critical dry years.

In Clear Creek and the Feather and American rivers, the analysis of the effects of Alternative 5 and Second Basis of Comparison for fall-run Chinook Salmon relied on the water temperature model output for the rivers at various locations downstream of the CVP and SWP facilities. The analysis of temperatures indicates similar temperatures and slightly greater likelihood of exceedance of thresholds under Alternative 5 as compared to the Second Basis of Comparison in the Feather River. There would be little change in flows or temperatures in Clear Creek under Alternative 5 relative to the Second Basis of Comparison. The effect of slightly increased temperatures is not reflected in the similar overall survival of fall-run Chinook Salmon eggs predicted by Reclamation's salmon mortality model for fall-run in the Feather and American rivers. In drier years, the likelihood of adverse temperature effects would be increased under Alternative 5 as compared to the Second Basis of Comparison.

Flow changes under Alternative 5 would likely have small effects on the availability of spawning and rearing habitat for fall-run Chinook Salmon in the Sacramento River system as indicated by the similarity in spawning WUA in the Sacramento, Feather, and American rivers under Alternative 5 and the Second Basis of Comparison. Fry and juvenile rearing WUA would be similar in the Sacramento River and this is reflected in the similarity in flow (habitat)-related mortality predicted by SALMOD under Alternative 5.

Through-Delta survival of juvenile fall-run Chinook Salmon would be similar under both Alternative 5 and Second Basis of Comparison as indicated by the DPM results and entrainment could be reduced as indicated by the OMR flow analysis. Overall, Alternative 5 likely would have similar or slightly greater adverse effects on the fall-run Chinook Salmon population in the Sacramento River watershed as compared to the Second Basis of Comparison, particularly in drier water year types.

Additional actions implemented under Alternative 5 could help improve conditions for fall-run Chinook Salmon relative to the Second Basis of Comparison, such as structural improvements for temperature management in the American River and actions intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities to improve the overall salvage survival of salmonids, including fall-run Chinook Salmon. The implementation of fish passage under Alternative 5 intended to address the limited availability of suitable habitat for winter-run and spring-run Chinook Salmon in the Sacramento River reaches downstream of Shasta Dam is unlikely to benefit fall-run Chinook Salmon unless passage is provided for adult fall-run Chinook Salmon. The effects of providing similar fish passage at Folsom Dam would also be uncertain for the same reason.

Overall, the results of the numerical models suggest the potential for greater adverse effects on fall-run Chinook Salmon under Alternative 5 as compared to the Second Basis of Comparison. However, discerning a meaningful difference between these two scenarios based on the quantitative results is difficult because of the similarity in results (generally differences less than 5 percent), the inherent uncertainty of the models, and the potential for offsetting benefits. Thus, it is concluded that the effects on fall-run Chinook Salmon would be similar under Alternative 5 and the Second Basis of Comparison.

Late Fall-Run Chinook Salmon

Changes in operations that influence temperature and flow conditions in the Sacramento River downstream of Keswick Dam could affect late fall-run Chinook Salmon. The following describes those changes and their potential effects.

Changes in Water Temperature

Monthly water temperature in the Sacramento River at Keswick Dam under Alternative and the Second Basis of Comparison generally would be similar (differences less than 0.5°F). Average monthly water temperatures in September under Alternative 5 would be lower (up to 0.9°F) in wetter years and higher (up to 1.2°F) in drier years. Similarly, water temperatures in October of critical years could be 0.9°F warmer under Alternative 5. A similar temperature pattern generally would be exhibited downstream at Ball’s Ferry, Jelly’s Ferry, Bend Bridge and Red Bluff, with average monthly temperatures in September progressively increasing (up to 3.2°F cooler at Red Bluff) during the wetter years.

Changes in Exceedances of Water Temperature Thresholds

Average monthly water temperatures under both Alternative 5 and Second Basis of Comparison would exceed the water temperature threshold of 56°F established in the Sacramento River at Red Bluff during some months, particularly in October, November, and April. The frequency of exceedance would be greatest in October, a month in which average monthly water could get as high as about 64°F. In October, average monthly water temperatures under Alternative 5 and Second Basis of Comparison would exceed the threshold 80 percent and 79 percent of the time, respectively. Water temperatures under Alternative 5 would exceed temperature thresholds about 2 percent more frequently than under the Second Basis of Comparison in October, 1 percent less frequently in November, and 1 percent more frequently in April.

Changes in Egg Mortality

For late fall-run Chinook Salmon in the Sacramento River, the long-term average egg mortality rate is predicted to range from approximately 2.4 to nearly 5 percent in all water year types under Alternative 5. Overall, egg mortality would be similar under Alternative 5 and the Second Basis of Comparison (Appendix 9C, Table B-2).

Changes in Weighted Usable Area

Modeling results indicate that there would be similar amounts of spawning habitat available for late fall-run Chinook Salmon in the Sacramento River from January through April under Alternative 5 and the Second Basis of Comparison (Appendix 9E, Table C-14-6). Modeling results indicate that, in general, there would be similar amounts of suitable late fall-run Chinook Salmon fry rearing habitat available under Alternative 5 and the Second Basis of Comparison (Appendix 9E, Table C-15-6).

A substantial fraction of late fall run Chinook Salmon juveniles oversummer in the Sacramento River before emigrating, which allows them to avoid predation through both their larger size and greater swimming ability. One implication of this life history strategy is that rearing habitat is most likely the limiting factor for late-fall-run Chinook Salmon, especially if availability of cool water determines the downstream extent of spawning habitat for late-fall-run salmon. Modeling results indicate that, there would be reduced amounts of suitable juvenile rearing habitat available in September (12 percent less) and November (8 percent less under Alternative 5 as compared to the Second Basis of Comparison. In other months the amount the amount of late fall-run Chinook Salmon juvenile rearing WUA would be similar under Alternative 5 and the Second Basis of Comparison (Appendix 9E, Table C-16-6).

Changes in SALMOD Output

SALMOD results indicate that potential juvenile production would be similar under Alternative 5 and the Second Basis of Comparison (Appendix 9D, Table B-2-26).

Changes in Delta Passage Model Output

For Late-Fall-Run, Delta survival was predicted to be slightly higher for Alternative 5 versus the Second Basis of Comparison for all 81 water years simulated by the Delta Passage Model (Appendix 9J). Median Delta survival across all years was 0.243 for Alternative 5 and 0.199 for the Second Basis of Comparison. Overall, there would be a slight increase in through-Delta survival for emigrating juvenile late fall-run Chinook Salmon under Alternative 5 as compared to the Second Basis of Comparison.

Changes in Delta Hydrodynamics

The late fall-run Chinook migration period overlaps with that of winter-run Chinook Salmon and they are most abundant in the Delta during the months of January February and March. On the Sacramento River near the confluence of Georgiana Slough, the median proportion of positive velocities under Alternative 5 was indistinguishable from the Second Basis of Comparison in January, February and March (Appendix 9K). On the San Joaquin River near the Mokelumne River confluence, the median proportion of positive velocities was slightly greater under Alternative 5 relative to Second Basis of Comparison in January and February and similar in March. In Old River downstream of the facilities, the median proportion of positive velocities was substantially higher under Alternative 5 during January and moderately higher in February. Values in

March were almost indistinguishable between scenarios. On Old River upstream of the facilities, the median proportion of positive velocities was moderately lower in January and February and slightly lower in March under Alternative 5 relative to Second Basis of Comparison. On the San Joaquin River downstream of Head of Old River, the median proportion of positive velocities was similar for both scenarios in January, February and March.

Changes in Junction Entrainment

At the junction of Georgiana Slough and the Sacramento River, median entrainment under Alternative 5 and the Second Basis of Comparison in January was essentially indistinguishable in January, February and March (Appendix 9L). Entrainment at the Head of Old River junction was similar to slightly lower under Alternative 5 relative to Second Basis of Comparison. For the Turner Cut junction, median entrainment under Alternative 5 was slightly lower in January and February relative to Second Basis of Comparison. In March, the difference in entrainment between scenarios was similar. At the Columbia Cut, Middle River and Old River junctions, patterns in entrainment between Alternative 5 and the Second Basis of Comparison were similar. At these junctions, entrainment was moderately lower under Alternative 5 during January and February and values were more similar in March.

Changes in Salvage

Salvage of late fall-run Chinook salmon is predicted to be substantially lower under Alternative 5 relative to the Second Basis of Comparison in January and February (Appendix 9M). In March salvage was only moderately lower under Alternative 5 relative to Second Basis of Comparison.

Summary of Effects on Late Fall-Run Chinook Salmon

The multiple model and analysis outputs described above characterize the anticipated conditions for late fall-run Chinook Salmon and their response to change under Alternative 5 as compared to the Second Basis of Comparison. For the purpose of analyzing effects on late fall-run Chinook Salmon in the Sacramento River, greater reliance was placed on the outputs from the SALMOD model because it integrates the available information on temperature and flows to produce estimates of mortality for each life stage and an overall, integrated estimate of potential late fall-run Chinook Salmon juvenile production. The output from SALMOD indicated that late fall-run Chinook Salmon production would be similar under Alternative 5 and the Second Basis of Comparison. The analyses attempting to assess the effects on routing, entrainment, and salvage of juvenile salmonids in the Delta suggest that salvage (as an indicator of potential losses of juvenile salmon at the export facilities) of Sacramento River-origin Chinook Salmon is predicted to be lower under Alternative 5 relative to the Second Basis of Comparison in every month.

These model results suggest that overall, Alternative 5 is likely to have less adverse effect on late fall-run Chinook Salmon in the Sacramento River as compared to the Second Basis of Comparison. Potential benefits may be enhanced under Alternative 5 by actions intended to increase the efficiency of the

Tracy and Skinner Fish Collection Facilities to improve the overall salvage survival of salmonids, including late fall-run Chinook Salmon. Thus, it is concluded that the potential for adverse effects on late fall-run Chinook Salmon would be less under Alternative 5 relative to the Second Basis of Comparison.

Steelhead

Changes in operations that influence temperature and flow conditions that could affect steelhead. The following describes those changes and their potential effects.

Changes in Water Temperature

Changes in water temperature could affect steelhead in the Sacramento, Feather, and American rivers, and Clear Creek. The following describes temperature conditions in those water bodies.

Sacramento River

Monthly water temperature in the Sacramento River at Keswick Dam under Alternative 5 and the Second Basis of Comparison generally would be similar (differences less than 0.5°F). Average monthly water temperatures in September under Alternative 5 would be lower (up to 0.9°F) in wetter years and higher (up to 1.2°F) in drier years. Similarly, water temperatures in October of critical years could be 0.9°F warmer under Alternative 5. A similar temperature pattern generally would be exhibited downstream at Ball’s Ferry, Jelly’s Ferry, Bend Bridge and Red Bluff, with average monthly temperatures in September progressively increasing (up to 3.2°F cooler at Red Bluff) during the wetter years (Appendix 6B, Table B-9-6).

Clear Creek

Average monthly water temperatures in Clear Creek at Igo under Alternative relative to the Second Basis of Comparison are generally predicted to be similar (less than 0.5°F differences) (Appendix 6B, Table B-3-6). Average monthly water temperatures during May under Alternative 5 would be up to 0.8°F lower than under the Second Basis of Comparison in all but critical water years.

Feather River

Long-term average monthly water temperature in the Feather River at the low flow channel under Alternative 5 relative to the Second Basis of Comparison generally would be similar (less than 0.5°F differences). Water temperatures could be up to 1.5°F warmer in November and December of some water year types and up to 1.2°F cooler in September of wetter years. Although temperatures in the river would become progressively higher in the downstream direction, the differences between Alternative 5 and Second Basis of Comparison exhibit a similar pattern at the downstream locations (Robinson Riffle and Gridley Bridge), with water temperature differences under Alternative 5 generally increasing in most water year types relative to the Second Basis of Comparison at the confluence with Sacramento. Water temperatures under Alternative 5 could be somewhat (0.8°F to 1.6°F) cooler on average and up to 3.9°F cooler (September) at the confluence with Sacramento River from July to September in wetter years.

American River

Average monthly water temperatures in the American River at Nimbus Dam under Alternative 5 generally would be similar (differences less than 0.5°F) to the Second Basis of Comparison, with the exception of during June and August of below normal years, when temperatures under Alternative 5 could be as much as 0.9°F higher. This pattern generally would persist downstream to Watt Avenue and the mouth, although temperatures under Alternative 5 would be up to 1.6°F and 2.1°F higher, respectively, than under the Second Basis of Comparison in June. In addition, average monthly water temperatures at the mouth generally would be lower than the Second Basis of Comparison in September, especially in wetter water year types when Alternative 5 could be up to 1.7°F cooler.

Changes in Exceedances of Water Temperature Thresholds

Changes in water temperature could result in the exceedance of established water temperature thresholds for steelhead in the Sacramento River, Clear Creek, and Feather River. The following describes the extent of those exceedance for each of those streams.

Sacramento River

As described in the life history accounts (Appendix), steelhead spawning in the mainstem Sacramento River generally occurs in the upper reaches from Keswick Dam downstream to near Balls Ferry, with most spawning concentrated near Redding. Most steelhead, however, spawn in tributaries to the Sacramento River. Spawning generally takes place in the January through March period when water temperatures in the river generally do not exceed 52°F under either Alternative 5 or Second Basis of Comparison. While there are no established temperature thresholds for steelhead rearing in the mainstem Sacramento River, average monthly temperatures when fry and juvenile steelhead are in the river would generally remain below 56°F at Balls Ferry except in August and September when this temperature would be exceeded at least 40 percent of the time under both the No Action Alternative and Second Basis of Comparison. However, water temperatures in the Sacramento River at Balls Ferry would exceed 56°F about 10 percent more often in September under the Second Basis of Comparison compared to Alternative 5. Overall, thermal conditions for steelhead in the Sacramento River would be similar under Alternative 5 and the Second Basis of Comparison.

Clear Creek

While there are no established temperature thresholds for steelhead spawning in Clear Creek, average monthly water temperatures in the river generally would not exceed 48°F during the spawning period (December to April) under either Alternative 5 or Second Basis of Comparison. Similarly, while there are no established temperature thresholds for steelhead rearing in Clear Creek, average monthly temperatures in throughout the year would not exceed 56°F at Igo. Overall, thermal conditions for steelhead in Clear Creek would be similar under Alternative 5 and the Second Basis of Comparison.

Feather River

Average monthly water temperatures under both Alternative 5 and the Second Basis of Comparison would on occasion exceed the water temperature threshold of 56°F established in the Feather River at Robinson Riffle for steelhead spawning and incubation during some months, particularly in October and November, and March and April, when temperature thresholds could be exceeded frequently (Appendix 9N).There would be a 1 percent exceedance of the 56°F threshold in December and no exceedances of the 56°F threshold in January and February under both Alternative 5 and the Second Basis of Comparison. However, the differences in the frequency of exceedance between Alternative 5 and Second Basis of Comparison during March and April would be relatively small with water temperatures under Alternative 5 exceeding the threshold about 1 percent more frequently in March and the same exceedance frequency (75 percent) as the Second Basis of Comparison in April.

The established water temperature threshold of 63°F for rearing from May through August would be exceeded often under both Alternative 5 and Second Basis of Comparison in May and June, but not at all in July and August. Water temperatures under Alternative 5 would exceed the rearing temperature threshold about 6 percent more frequently than under the Second Basis of Comparison in May, but no more frequently in June. Temperature conditions in the Feather River under Alternative 5 could be more likely to result in adverse effects on steelhead spawning and rearing than under the Second Basis of Comparison because of the slightly increased frequency of exceedance of the 56°F spawning threshold in March and the somewhat increased frequency of exceedance of the 63°F rearing threshold in May.

American River

In the American River, the water temperature threshold for steelhead rearing (May through October) is 65°F at the Watt Avenue Bridge. Average monthly water temperatures would exceed this threshold often under both Alternative 5 and Second Basis of Comparison, especially in the July through September period when the threshold is exceeded nearly all of the time. In addition, the magnitude of the exceedance would be high, with average monthly water temperatures sometimes higher than 76°F. The differences in exceedance frequency between Alternative 5 and Second Basis of Comparison, however, would be relatively small (differences within 1 percent), except in September, when average monthly water temperatures under Alternative 5 would exceed 65°F about 6 percent less frequently than under the Second Basis of Comparison. Temperature conditions in the American River under Alternative 5 could increase the likelihood of adverse effects on steelhead rearing than under the Second Basis of Comparison because of the increased frequency of exceedance of the 65°F rearing threshold in some months.

Changes in Weighted Usable Area

The following describes changes in WUA for steelhead in the Sacramento, Feather, and American rivers and Clear Creek.

Sacramento River

Modeling results indicate that, in general, there would be similar amounts of suitable steelhead spawning habitat available from December through March under Alternative 5 as compared to the Second Basis of Comparison (Appendix 9E, Table C-20-6).

Clear Creek

As described above, flows in Clear Creek below Whiskeytown Dam are not anticipated to differ under Alternative 5 relative to the Second Basis of Comparison except in May due to the release of spring attraction flows in accordance with the 2009 NMFS BO. Therefore, there would be no change in the amount of potentially suitable spawning and rearing habitat for steelhead (as indexed by WUA) available under Alternative 5 as compared to the Second Basis of Comparison.

Feather River

As described above, Flows in the low flow channel of the Feather River are not anticipated to differ under Alternative 5 relative to the Second Basis of Comparison. Therefore, there would be no change in the amount of potentially suitable spawning habitat for steelhead (as indexed by WUA) available under Alternative 5 as compared to the Second Basis of Comparison. The majority of spawning activity by steelhead in the Feather River occurs in this reach with a lesser amount of spawning occurring downstream of the Thermalito Complex.

Modeling results indicate that, in general, there would be similar amounts of spawning habitat for steelhead in the Feather River below Thermalito available from December through April under Alternative 5 and the Second Basis of Comparison.

American River

Modeling results indicate that, in general, there would be similar amounts of spawning habitat for steelhead in the American River downstream of Nimbus Dam available from December through April under Alternative 5 and the Second Basis of Comparison.

Changes in Delta Hydrodynamics

Sacramento River-origin steelhead generally move through the Delta during spring however there is less information on their timing relative to Chinook salmon. Thus, hydrodynamics in the entire January through June period have the potential to affect juvenile steelhead.

On the Sacramento River near the confluence of Georgiana Slough, the median proportion of positive velocities under Alternative 5 was moderately lower relative to the Second Basis of Comparison from January to April and slightly lower in May and June (Appendix 9K). On the San Joaquin River near the Mokelumne River confluence, the median proportion of positive velocities was slightly greater under Alternative 5 relative to Second Basis of Comparison in January, February, April and May and similar in March and June. In Old River downstream of the facilities, the median proportion of positive velocities was substantially higher under Alternative 5 during January, April, and May and moderately higher in February. Values in March and June were almost indistinguishable between scenarios. On Old River upstream of the facilities, the median proportion of positive velocities was moderately lower in January and February, slightly lower March and June, and slightly higher in April and May under Alternative 5 relative to Second Basis of Comparison. On the San Joaquin River downstream of Head of Old River, the median proportion of positive velocities was similar for both scenarios in January, February, March and June, but slightly to moderately lower in April and May.

Summary of Effects on Steelhead

The multiple model and analysis outputs described above characterize the anticipated conditions for steelhead and their response to change under Alternative 5 as compared to the Second Basis of Comparison. The analysis of the effects of Alternative and Second Basis of Comparison for steelhead relied on the WUA analysis for habitat and water temperature model output for the rivers at various locations downstream of the CVP and SWP facilities. The WUA analysis indicated that the availability of steelhead spawning and rearing habitat in Clear Creek and steelhead spawning habitat in the Sacramento, Feather and American rivers would be similar under Alternative 5 and the Second Basis of Comparison. The analysis of temperatures indicates somewhat higher temperatures and greater likelihood of exceedance of thresholds under Alternative 5 as compared to the Second Basis of Comparison in the Sacramento and Feather rivers. In drier years, the likelihood of adverse temperature effects would be increased under Alternative 5 as compared to the Second Basis of Comparison. There would be little change in flows or temperatures in Clear Creek under Alternative 5 relative to the Second Basis of Comparison.

These numerical model results suggest that overall, effects on steelhead could be slightly more adverse under Alternative 5 than under the Second Basis of Comparison, particularly in the Feather and American rivers. However, implementation of a fish passage program under Alternative 5 intended to address the limited availability of suitable habitat for steelhead in the Sacramento River reaches downstream of Keswick Dam and in the American River could provide a benefit to Central Valley steelhead in the Sacramento and American rivers. This is particularly important in light of anticipated increases in water temperature associated with climate change in 2030. In addition to fish passage, preparation and implementation of an HGMP for steelhead at the Nimbus Fish Hatchery and actions under Alternative 5 intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities could benefit steelhead under Alternative 5 in comparison to the Second Basis of Comparison. Thus, on balance and over the long term, the adverse effects on steelhead under Alternative 5 would be less than those under the Second Basis of Comparison.

Green Sturgeon

Changes in operations that influence temperature and flow conditions could affect Green Sturgeon. The following describes those changes and their potential effects.

Changes in Water Temperature

Changes in water temperature could affect Green Sturgeon in the Sacramento and Feather rivers. The following describes temperature conditions in those water bodies.

Sacramento River

Monthly water temperature in the Sacramento River at Keswick Dam under Alternative and the Second Basis of Comparison generally would be similar (differences less than 0.5°F). Average monthly water temperatures in September under Alternative 5 would be lower (up to 0.9°F) in wetter years and higher (up to 1.2°F) in drier years. Similarly, water temperatures in October of critical years could be 0.9°F warmer under Alternative 5. (Appendix 6B). A similar pattern in temperatures generally would be exhibited at downstream locations along the Sacramento River (i.e., Ball's Ferry Jelly's Ferry, Bend Bridge, Red Bluff, Hamilton City, and Knights Landing), with differences in average monthly temperatures at Knights Landing progressively increasing (up to 1.0°F warmer) in June and up to up to 4.6°F cooler in September of wetter years under Alternative 5 relative to the Second Basis of Comparison.

Feather River

Long-term average monthly water temperature in the Feather River at the low flow channel under Alternative 5 relative to the Second Basis of Comparison generally would be similar (less than 0.5°F differences). Water temperatures could be up to 1.5°F warmer in November and December of some water year types and up to 1.2°F cooler in September of wetter years. Although temperatures in the river would become progressively higher in the downstream direction, the differences between Alternative 5 and Second Basis of Comparison exhibit a similar pattern at the downstream locations (Robinson Riffle and Gridley Bridge), with water temperature differences under Alternative 5 generally increasing in most water year types relative to the Second Basis of Comparison at the confluence with Sacramento. Water temperatures under Alternative 5 could be somewhat (0.8°F to 1.6°F) cooler on average and up to 3.9°F cooler (September) at the confluence with Sacramento River from July to September in wetter years.

Changes in Exceedances of Water Temperature Thresholds

Changes in water temperature could result in the exceedance of established water temperature thresholds for Green Sturgeon in the Sacramento and Feather rivers. The following describes the extent of those exceedance for each of those rivers.

Sacramento River

Average monthly water temperatures in the Sacramento River at Bend Bridge under both Alternative 5 and Second Basis of Comparison would exceed the water temperature threshold of 63°F established for Green Sturgeon larval rearing in August and September, with exceedances under Alternative 5 occurring about 7 percent of the time in August and about 12 percent of the time in September. This is 1 to 2 percent more frequently than under the Second Basis of Comparison. Average monthly water temperatures at Bend Bridge could be as high as about 73°F during this period. Temperature conditions in the Sacramento

River under Alternative 5 could be more likely to result in adverse effects on Green Sturgeon rearing than under the Second Basis of Comparison because of the slightly increased frequency of exceedance of the 63°F threshold in August and September.

Feather River

Average monthly water temperatures in the Feather River at Gridley Bridge under both Alternative 5 and Second Basis of Comparison would exceed the water temperature threshold of 64°F established for Green Sturgeon spawning, incubation, and rearing in May, June, and September; no exceedances under either scenarios would occur in July and August. The frequency of exceedances would be high, with both Alternative 5 and Second Basis of Comparison exceeding the threshold in June nearly 100 percent of the time. The magnitude of the exceedance also would be substantial, with average monthly temperatures higher than 72°F in June, and higher than 75°F in July and August. Water temperatures under Alternative 5 would exceed the threshold about 7 percent more frequently in May than under the Second Basis of Comparison and about 33 percent less frequently in September. Temperature conditions in the Feather River under Alternative 5 could be more likely to result in adverse effects on Green Sturgeon rearing than under the Second Basis of Comparison because of the increased frequency of exceedance of the 64°F threshold in May. The reduction in exceedance frequency in September may have less effect on rearing Green Sturgeon as many juvenile sturgeon may have migrated downstream to the lower Sacramento River and Delta by this time.

Changes in Delta Outflow

As described in Appendix 9P, mean (March to July) Delta outflow was used an indicator of potential year class strength and the likelihood of producing a strong year class of sturgeon. The median value over the 82-year CalSim II modeling period of mean (March to July) Delta outflow was predicted to be 16 percent higher under Alternative 5 than under the Second Basis of Comparison. In addition, the likelihood of mean (March to July) Delta outflow exceeding the threshold of 50,000 cfs was the same under both alternatives.

Summary of Effects on Green Sturgeon

The temperature threshold analysis in the Sacramento and Feather rivers both suggest that average monthly water temperatures under Alternative 5 would exceed thresholds for Green Sturgeon more frequently than under the Second Basis of Comparison, although the frequency of exceedance would be relatively small (1-2 percent). However, average monthly water temperatures likely mask daily temperatures excursions that could exceed important thresholds. Therefore, while the differences in threshold exceedance are relatively minor, the likelihood of adverse effects on Green Sturgeon under Alternative 5 would likely be greater than under the Second Basis of Comparison. The analysis based on Delta outflows suggests that Alternative 5 provides higher mean (March to July) outflows which could result in stronger year classes of juvenile sturgeon relative to the Second Basis of Comparison. However, early life stage survival in the natal rivers is crucial in development of a strong year class; therefore, based primarily on the analysis of water temperatures, Alternative 5 could be more likely to result in adverse effects on Green Sturgeon than the Second Basis of Comparison.

White Sturgeon

Changes in water temperature conditions in the Sacramento and Feather rivers would be the same as those described above for Green Sturgeon.

The water temperature threshold established for White Sturgeon spawning and egg incubation in the Sacramento River at Hamilton City is 61°F from March through June. Although there would be no exceedances of the threshold in March and April, water temperatures under both Alternative 5 and Second Basis of Comparison would exceed this threshold in May and June. The average monthly water temperatures in May under Alternative 5 would exceed this threshold about 56 percent of the time (about 7 percent more frequently than under the Second Basis of Comparison). In June, the temperature under Alternative 5 would exceed the threshold about 87 percent of the time (about 13 percent more frequently than the Second Basis of Comparison). Average monthly water temperatures during May and June under Alternative 5 would as high as about 65°F.

Changes in Delta outflows would be the same as those described above for Green Sturgeon. Mean (March to July) Delta outflow was predicted to be 13 percent higher under the No Action Alternative than under the Second Basis of Comparison. In addition, the likelihood of mean (March to July) Delta outflow exceeding the threshold of 50,000 cfs was the same under both alternatives.

Summary of Effects on White Sturgeon

The increased frequency of exceedance of water temperature thresholds under Alternative 5 could increase the potential for adverse effects on White Sturgeon relative to the Second Basis of Comparison. The analysis based on Delta outflows suggests that the No Action Alternative provides higher mean (March to July) outflows which could result in stronger year classes of juvenile sturgeon relative to the Second Basis of Comparison. However, early life stage survival in the natal rivers is crucial in development of a strong year class; therefore, based primarily on the analysis of water temperatures, Alternative could be more likely to result in adverse effects on White Sturgeon than the Second Basis of Comparison.

Delta Smelt

The potential effects of the No Action Alternative as compared to the Second Basis of Comparison were analyzed based on differences in proportional entrainment and the fall abiotic index as described below.

As described in Appendix 9G, a proportional entrainment regression model (based on Kimmerer 2008, 2011) was used to simulate adult Delta Smelt entrainment, as influenced by OMR flow in December through March. Results indicate that the percentage of entrainment of migrating and spawning adult Delta Smelt under Alternative 5 would be 7 to 8.3 percent, depending on the water year type, with a long-term average percent entrainment of 7.6 percent. Percent entrainment of adult Delta Smelt under Alternative 5 would be similar to results under Second Basis of Comparison. Under the Second Basis of Comparison, the long-term average entrainment would be 9 percent.

A proportional entrainment regression model (based on Kimmerer 2008) also was used to simulate larval and early juvenile Delta Smelt entrainment, as influenced by OMR flow and location of X2 in March through June. Results indicate that the percentage of entrainment of larval and early juvenile Delta Smelt under Alternative 5 would be 1.3 to 19.3 percent, depending on the water year type, with a long term average percent entrainment of 8.6 percent, and highest entrainment under Critical water year conditions. Percent entrainment of larval and early juvenile Delta Smelt under Alternative 5 would be lower than results under the Second Basis of Comparison by up to 9.4 percent. Under the Second Basis of Comparison, the long-term average percent entrainment would be 15.5 percent, and highest entrainment would occur under critical dry water year conditions, at 23.6 percent.

The predicted position of Fall X2 (in September through December) is used as an indicator of fall abiotic habitat index for Delta Smelt. Feyrer et al. (2010) used X2 location as an indicator of the extent of habitat available with suitable salinity for the rearing of older juvenile Delta Smelt. Feyrer et al. (2010) concluded that when X2 is located downstream (west) of the confluence of the Sacramento and San Joaquin Rivers, at a distance of 70 to 80 km from the Golden Gate Bridge, there is a larger area of suitable habitat. The overlap of the low salinity zone (or X2) with the Suisun Bay/Marsh results in a two-fold increase in the habitat index (Feyrer et al. 2010).

The average September through December X2 position in km was used to evaluate the fall abiotic habitat availability for Delta Smelt under the Alternatives. X2 values simulated in the CalSim II model for each Alternative were averaged over September through December, and compared. Results indicate that under the No Action Alternative, the X2 position would range from 75.8 km to 92.3 km, depending on the water year type, with a long term average X2 position of 84 km. The most eastward location of X2 is predicted under Critical water year conditions. The X2 positions predicted under Alternative 5 would be similar to results under the Second Basis of Comparison in drier water year types. In wetter years, the X2 location would be further west under Alternative 5 than under the Second Basis of Comparison, by 6.1 to 9.8 km.

Overall, Alternative 5 likely would result in better conditions for Delta Smelt than would the Second Basis of Comparison, primarily due to lower percentage entrainment for larval and juvenile life stages, and more favorable location of Fall X2 in wetter years, and on average. Given the current condition of the Delta Smelt population, even small differences between alternatives may be important.

Longfin Smelt

The effects of the Alternative 5 as compared to the Second Basis of Comparison were analyzed based on the direction and magnitude of OMR flows during the period (December through June) when adult, larvae, and young juvenile Longfin Smelt are present in the Delta in the vicinity of the export facilities (Appendix 5A). The analysis was augmented with calculated Longfin Smelt abundance index values (Appendix 9G) per Kimmerer et al. (2009), which is based on the assumptions that lower X2 values reflect higher flows and that transporting Longfin Smelt farther downstream leads to greater Longfin Smelt survival. The index value indicates the relative abundance of Longfin Smelt and not the calculated population.

Under Alternative 5, Longfin Smelt abundance index values range from 1,204 under critical water year conditions to a high of 16,683 under wet water year conditions, with a long-term average value of 8,015. Under the Second Basis of Comparison, Longfin Smelt abundance index values range from 947 under critical water year conditions to a high of 15,822 under wet water year conditions, with a long-term average value of 7,257.

Results indicate that the Longfin Smelt abundance index values would be greater in every water year type under Alternative 5 than under the Second Basis of Comparison, with a long-term average index for Alternative 5 that is about 10 percent higher than the long term average index for the Second Basis of Comparison. For below normal, dry, and critical water years, the Longfin Smelt abundance index values would be over 20 percent greater under Alternative 5 than under the Second Basis of Comparison, with the greatest difference (30.8 percent) predicted under dry conditions.

Overall, based on the lower frequency and magnitude of negative OMR flows and the higher Longfin Smelt abundance index values, especially in dry and critical years, Alternative 5 would be likely have a lower potential for adverse effects on the Longfin Smelt population as compared to the Second Basis of Comparison.

Sacramento Splittail

Under Alternative 5, flows entering the Yolo Bypass over the Fremont Weir generally would be slightly lower compared to the Second Basis of Comparison (Appendix 5A, Table C-26-6), thus potentially providing lower value to Sacramento Splittail because of the lower area of potential habitat (inundation) and the lower frequency of inundation. Given the relatively minor changes in flows into the Yolo Bypass, and the inherent uncertainty associated with the resolution of the CalSim II model (average monthly outputs), it is concluded that no definitive difference in effects on Sacramento Splittail between Alternative 5 and the Second Basis of Comparison could be discerned.

Reservoir Fishes

Changes in Available Habitat (Storage)

As described in Chapter 5, Surface Water Resources and Water Supplies, changes in CVP and SWP water supplies and operations under Alternative 5 as compared to the Second Basis of Comparison generally would result in lower reservoir storage in CVP and SWP reservoirs in the Central Valley Region. Storage levels in Shasta Lake, Lake Oroville, and Folsom Lake would be lower under Alternative 5 as compared to the Second Basis of Comparison in the fall and winter months due to the inclusion of Fall X2 criteria under Alternative 5.

The highest reductions in Shasta Lake and Lake Oroville storage could be in excess of 20 percent. Storage in Folsom Lake could be reduced up to around 10 percent in some months of some water year types. Additional information related to monthly reservoir elevations is provided in Appendix 5A, CalSim II and DSM2 Modeling. The reduction in reservoir storage under Alternative 5 may suggest that the amount of habitat for reservoir fishes could be reduced under Alternative 5 as compared to the Second Basis of Comparison. However, it is anticipated that aquatic habitat within the CVP and SWP water supply reservoirs is not limiting, such that this potential reduction in habitat may have little adverse effect on reservoir fishes.

Changes in Black Bass Nesting Success

Black bass nest survival in CVP and SWP reservoirs is anticipated to be near 100 percent in March and April due to increasing reservoir elevations. For May, the likelihood of nest survival for Largemouth Bass in Lake Shasta being in the 40 to 100 percent range is about 2 percent higher under Alternative 5 as compared to the Second Basis of Comparison. For June, the likelihood of nest survival being greater than 40 percent for Largemouth Bass is similar (within 1 percent) under Alternative 5 and Second Basis of Comparison; however, nest survival of greater than 40 percent is likely only in about 20 percent of the years evaluated. The likelihood of nest survival for Smallmouth Bass in Lake Shasta exhibits nearly the same pattern. For Spotted Bass, the likelihood of nest survival being greater than 40 percent is high (100 percent) in May under both Alternative 5 and the Second Basis of Comparison. For June, Spotted Bass nest survival would be less than for May due to greater daily reductions in water surface elevation as Shasta Lake is drawn down. The likelihood of survival being greater than 40 percent is higher (by about 12 percent) under Alternative 5 as compared to the Second Basis of Comparison.

For May and June, the likelihood of nest survival for Largemouth Bass in Lake Oroville being in the 40 to 100 percent range is higher under Alternative 5 as compared to the Second Basis of Comparison, about 13 percent higher in May and about 4 percent higher in June. However, June nest survival of greater than 40 percent is likely only in about 40 percent of the years evaluated. The likelihood of nest survival for Smallmouth Bass in Lake Oroville exhibits nearly the same pattern. For Spotted Bass, the likelihood of nest survival being greater than 40 percent is 100 percent in May under Alternative 5 as compared to about 94 percent under the Second Basis of Comparison. For June, Spotted Bass survival would be less than for May due to greater daily reductions in water surface elevation as Lake Oroville is drawn down. The likelihood of survival being greater than 40 percent is substantially higher (on the order of 20 percent) under Alternative 5 as compared to the Second Basis of Comparison.

Black bass nest survival in Folsom Lake is near 100 percent in March, April, and May due to increasing reservoir elevations. For June, the likelihood of nest survival for Largemouth Bass and Smallmouth Bass in Folsom Lake being in the 40 to 100 percent range is somewhat (around 7 percent) higher under Alternative 5 than under the Second Basis of Comparison. For Spotted Bass, nest survival for June would be less than for May due to greater daily reductions in water surface elevation. However, the likelihood of survival being greater than 40 percent is similar under Alternative 5 as compared to the Second Basis of Comparison.

Summary of Effects on Reservoir Fishes

Reservoir storage is anticipated to be reduced under Alternative 5 relative to the Second Basis of Comparison and this reduction could affect the amount of warm and cold water habitat available within the reservoirs. However, it is unlikely that aquatic habitat within the CVP and SWP water supply reservoirs is limiting.

The analysis of black bass nest survival based on changes in water surface elevation during the spawning period indicated that the likelihood of high (>40 percent) nest survival in most of the reservoirs under Alternative 5 would be similar under Alternative 5 and the Second Basis of Comparison. Overall, the results of the habitat and nest survival analysis suggest that effects on reservoir fishes would be similar under the No Action Alternative and the Second Basis of Comparison.

Other Species

Several other fish species could be affected by changes in operations that influence temperature and flow. The following describes the extent of these changes and the potential effects on these species.

Pacific Lamprey

Little information is available on factors that influence populations of Pacific Lamprey in the Sacramento River, but they are likely affected by many of the same factors as salmon and steelhead because of the parallels in their life cycles.

Changes in Water Temperature

The following describes anticipated changes in average monthly water temperature in the Sacramento, Feather, and American rivers and the potential for those changes to affect Pacific Lamprey.

Sacramento River

Monthly water temperature in the Sacramento River at Keswick Dam under Alternative 5 and the Second Basis of Comparison generally would be similar (differences less than 0.5°F). Average monthly water temperatures in September under Alternative 5 would be lower (up to 0.9°F) in wetter years and higher (up to 1.2°F) in drier years. Similarly, water temperatures in October of critical years could be 0.9°F warmer under Alternative 5 (Appendix 6B, Table 5-5-6). A similar pattern in temperatures generally would be exhibited at downstream locations along the Sacramento River (i.e., Ball's Ferry Jelly's Ferry, Bend Bridge, Red Bluff, Hamilton City, and Knights Landing), with differences in average monthly temperatures at Knights Landing progressively increasing (up to 1.0°F warmer) in June and up to up to 4.6°F cooler in September of wetter years under Alternative 5 relative to the Second Basis of Comparison. Given the generally minor differences in flows and water temperatures between Alternative 5 and the Second Basis of Comparison, it is anticipated that the effect on Pacific Lamprey in the Sacramento River generally would be the same under both scenarios.

Feather River

Long-term average monthly water temperature in the Feather River at the low flow channel under Alternative 5 relative to the Second Basis of Comparison generally would be similar (less than 0.5°F differences). Water temperatures could be up to 1.5°F warmer in November and December of some water year types and up to 1.2°F cooler in September of wetter years. Although temperatures in the river would become progressively higher in the downstream direction, the differences between Alternative 5 and Second Basis of Comparison exhibit a similar pattern at the downstream locations (Robinson Riffle and Gridley Bridge), with water temperature differences under Alternative 5 generally increasing in most water year types relative to the Second Basis of Comparison at the confluence with Sacramento. Water temperatures under Alternative 5 could be somewhat (0.8°F to 1.6°F) cooler on average and up to 3.9°F cooler (September) at the confluence with Sacramento River from July to September in wetter years.

Due to the similarity of water temperatures under Alternative 5 and Second Basis of Comparison from January through August, there would be little difference in potential effects on Pacific Lamprey adults during their upstream migration.

American River

Average monthly water temperatures in the American River at Nimbus Dam under Alternative 5 generally would be similar (differences less than 0.5°F) to the Second Basis of Comparison, with the exception of during June and August of below normal years, when temperatures under Alternative 5 could be as much as 0.9°F higher. This pattern generally would persist downstream to Watt Avenue and the mouth, although temperatures under Alternative 5 would be up to 1.6°F and 2.1°F higher, respectively, than under the Second Basis of Comparison in June. Due to the similarity of water temperatures under Alternative 5 and Second Basis of Comparison from January through May, there would be little difference in potential effects on Pacific Lamprey adults during their upstream migration. The higher water temperatures during June and August may increase the likelihood of adverse effects on Pacific Lamprey during their holding, and spawning periods.

Summary of Effects on Pacific Lamprey

In general, Pacific Lamprey can tolerate higher temperatures than salmonids, up to around 72°F during their entire life history. Because lamprey ammocoetes remain in the river for several years, any substantial flow reductions or temperature increases could result in adverse effects on larval larvae. Given similarity in water temperatures during their spawning and incubation period, it is likely that Alternative 5 would have a similar potential to affect Pacific Lamprey in the Sacramento, Feather, and American rivers than would the Second Basis of Comparison. This conclusion likely applies to other species of lamprey that inhabit these rivers (e.g., River Lamprey).

Striped Bass, American Shad, and Hardhead

Changes in operations influence temperature and flow conditions that could affect Striped Bass, American Shad, and Hardhead. The following describes those changes and their potential effects.

Changes in Water Temperature

Changes in water temperature that affect Striped Bass, American Shad, and Hardhead could occur in the Sacramento, Feather, and American rivers. The following describes temperature conditions in those water bodies.

Sacramento River

As described above for lampreys, monthly water temperature in the Sacramento River at Keswick Dam under Alternative and the Second Basis of Comparison generally would be similar (within about 0.5°F). Average monthly water temperatures in September under Alternative 5 would be lower (up to 0.9°F) in wetter years and higher (up to 1.2°F) in drier years. Similarly, water temperatures in October of critical years could be 0.9°F warmer under Alternative 5 (Appendix 6B, Table 5-5-6). A similar temperature pattern generally would be exhibited downstream at Ball’s Ferry, Jelly’s Ferry, and Bend Bridge, with average monthly temperatures in June progressively increasing by a small margin under Alternative 5 relative to the Second Basis of Comparison.

Feather River

Long-term average monthly water temperature in the Feather River at the low flow channel under Alternative 5 relative to the Second Basis of Comparison generally would be similar (less than 0.5°F differences). Water temperatures could be up to 1.5°F warmer in November and December of some water year types and up to 1.2°F cooler in September of wetter years. Although temperatures in the river would become progressively higher in the downstream direction, the differences between Alternative 5 and Second Basis of Comparison exhibit a similar pattern at the downstream locations (Robinson Riffle and Gridley Bridge), with water temperature differences under Alternative 5 generally increasing in most water year types relative to the Second Basis of Comparison at the confluence with the Sacramento River. Water temperatures under Alternative 5 could be somewhat (0.8°F to 1.6°F) cooler on average and up to 3.9°F cooler (September) at the confluence with Sacramento River from July to September in wetter years.

American River

Average monthly water temperatures in the American River at Nimbus Dam under Alternative 5 generally would be similar (differences less than 0.5°F) to the Second Basis of Comparison, with the exception of during June and August of below normal years, when differences under Alternative 5 could be as much as 0.9°F higher. This pattern generally would persist downstream to Watt Avenue and the mouth, although temperatures under Alternative 5 would be up to 1.6°F and 2.1°F higher, respectively, than under the Second Basis of Comparison in June.

Changes in Position of X2

Alternative 5 would result in a more westward X2 position as compared to the Second Basis of Comparison during April and May, with similar values in June (Appendix 5A, Section C Table C-16-6). Based on Kimmerer (2002) and Kimmerer et al. (2009), this change in X2 would likely increase the survival index and the habitat index as measured by salinity for Striped Bass and abundance and habitat index for American Shad.

Summary of Effects on Striped Bass, American Shad, and Hardhead

Because Striped Bass, American Shad, and Hardhead can tolerate higher temperatures than salmonids, it is unlikely that the slightly increased temperatures during some months under Alternative 5 would have substantial adverse effects on these species in the American River. Given the generally minor differences in water temperatures between Alternative 5 and the Second Basis of Comparison, it is anticipated that the effect of water temperatures on Striped Bass, American Shad, and Hardhead generally would be the same under both scenarios. Overall, Alternative 5 likely would have similar effects on Hardhead and a slightly lower potential for adverse effects on Striped Bass and American Shad as compared to the Second Basis of Comparison, primarily due to the potential for increased survival for these two species during larval and juvenile life stages, and more favorable location of Spring X2 on average.

Stanislaus River/Lower San Joaquin River

Fall-Run Chinook Salmon

Changes in operations influence temperature and flow conditions that could affect fall-run Chinook Salmon in the Stanislaus River downstream of Goodwin Dam and in the San Joaquin River below Vernalis. The following describes those changes and their potential effects.

Changes in Water Temperature (Stanislaus River)

Average monthly water temperatures in the Stanislaus River at Goodwin Dam under Alternative 5 and Second Basis of Comparison generally would be similar (differences less than 0.5°F), except in August through October when long-term average monthly temperatures could be up to 1.0°F warmer than under the Second Basis of Comparison. These differences would be of higher magnitude in drier years with average monthly water temperatures in September as much as 1.9°F warmer under Alternative 5 as compared to the Second Basis of Comparison (Appendix 6B, Table B-17-6).

Downstream at Orange Blossom Bridge, average monthly water temperatures in October and April under Alternative 5 would be lower in all water year types than the Second Basis of Comparison by as much as 1.4°F in October and 1.6°F in April. In most other months, long-term average monthly water temperatures under Alternative 5 generally would be similar to water temperatures under the Second Basis of Comparison. Water temperatures under Alternative 5 could be up to 1.3°F warmer in drier years from July to September than under the Second Basis of Comparison. (Appendix 6B, Table B-18-6).

Downstream at the confluence with the San Joaquin River, average monthly water temperatures in October, April and May would be lower by 2.0°F in October, 1.9°F in April and 0.6°F in May. Differences in water temperatures between Alternative 5 and the Second Basis of Comparison would be even greater in these months in some water year types. In most other months, long-term average monthly water temperatures under Alternative 5 generally would be similar, but could be somewhat higher (up to 1.1°F) in June, compared to the Second Basis of Comparison (Appendix 6B, Table B-19-6).

Changes in Exceedance of Water Temperature Thresholds (Stanislaus River)

While specific water temperature thresholds for fall-run Chinook Salmon in the Stanislaus River are not established, temperatures generally suitable for fall-run Chinook Salmon spawning (56°F) would be exceeded in October and November over 30 percent of the time in the Stanislaus River at Goodwin Dam under Alternative 5 ((Appendix 6B, Figure B-17-1 and B-17-2)). Similar exceedances would occur under the Second Basis of Comparison, although up to 10 percent more frequently in November. Water temperatures for rearing from January to May generally would be below 56°F, except in May when average monthly water temperatures would reach about 60°F under both conditions (Appendix 6B, Figure B-17-8).

Downstream at Orange Blossom Bridge, water temperatures suitable for fall-run Chinook Salmon spawning would be exceeded frequently under both Alternative 5 and Second Basis of Comparison during October and November. Under Alternative 5, average monthly water temperatures would exceed 56°F about 57 percent of the time in October (Appendix 6B, Figure B-18-1). This, however, would be about 28 percent less frequently than under the Second Basis of Comparison. In November, average monthly water temperatures would exceed 56°F about 33 percent of the time under Alternative 5, which would be about 5 percent more frequently than under the Second Basis of Comparison (Appendix 6B, Figure B-18-2).

During January through May, rearing fall-run Chinook Salmon under Alternative 5 would be subjected to average monthly water temperatures that exceed 56° in March (less than 10 percent of the time) and May (about 30 percent of the time) under Alternative 5 which is about 10 percent more frequently than under the Second Basis of Comparison (Appendix 6B, Figure B-18-8).

Changes in Egg Mortality (Stanislaus River)

For fall-run Chinook Salmon in the Stanislaus River, the long-term average egg mortality rate is predicted to be around 8.5 percent, with higher mortality rates (in excess of 15 percent) occurring in critical dry years under Alternative 5. Overall, egg mortality would be similar under Alternative 5 and the Second Basis of Comparison (Appendix 9C, Table B-8).

Changes in Delta Hydrodynamics

San Joaquin River-origin fall run Chinook salmon smolts are most abundant in the Delta during the months of April, May and June. Near the confluence of the San Joaquin River and the Mokelumne River, the median proportion of positive velocities was slightly to moderately higher under Alternative 5 relative to Second Basis of Comparison in April and May, respectively whereas values in June were similar (Appendix 9K). On Old River downstream of the facilities, the median proportion of positive velocities was substantially higher in April and May and slightly higher in June under Alternative 5 relative to Second Basis of Comparison. In Old River upstream of the facilities, the median proportion of positive velocities was slightly higher under Alternative 5 April and May and slightly lower in June. On the San Joaquin River downstream of the Head of Old River, the median proportion of positive velocities was slightly to moderately lower under Alternative 5 relative to Second Basis of Comparison in April and May, respectively, and similar in June.

Changes in Junction Entrainment

Entrainment at the Head of Old River junction was substantially higher under Alternative 5 relative to Second Basis of Comparison during the months of April and May and slightly lower in June (Appendix 9L). For the Turner Cut junction, median entrainment under Alternative 5 was moderately lower in April and May relative to Second Basis of Comparison and slightly lower in June. At the Columbia Cut junction, median entrainment under Alternative 5 was slightly lower in June relative to the Second Basis of Comparison. Median entrainment was substantially lower under Alternative 5 relative to Second Basis of Comparison in April and May. A similar pattern of entrainment under Alternative 5 relative to Second Basis of Comparison was observed at the Middle River and Old River junctions.

Summary of Effects on Fall-Run Chinook Salmon

The multiple model and analysis outputs described above characterize the anticipated conditions for fall-run Chinook Salmon and their response to change under the No Action Alternative as compared to the Second Basis of Comparison. In the Stanislaus River, the analysis of the effects of the No Action Alternative and Second Basis of Comparison for fall-run Chinook Salmon relied on the water temperature model output for the rivers at various locations downstream of Goodwin Dam. The analysis of temperatures indicates lower temperatures and a slightly lower likelihood of exceedance of suitable temperatures for spawning and rearing of fall-run Chinook Salmon under Alternative 5 as compared to the Second Basis of Comparison in the Stanislaus

River below Goodwin Dam and in the San Joaquin River at Vernalis. The effect of lower temperatures is not reflected in the similar overall mortality of fall-run Chinook Salmon eggs predicted by Reclamation's salmon survival model for fall-run in the Stanislaus River. As described above, the instream flow patterns under Alternative 5 are anticipated to benefit fall-run Chinook Salmon in the Stanislaus River and downstream in the lower San Joaquin River below Vernalis.

Implementation of a fish passage project under Alternative 5, primarily intended to address the limited availability of suitable habitat for steelhead in the Stanislaus River reaches downstream of Goodwin Dam, is not likely to provide benefit to fall-run Chinook Salmon unless passage for fall-run Chinook Salmon was provided and additional habitat could be accessed. Any potential benefit to fall-run Chinook Salmon is uncertain. However, actions implemented under Alternative 5 intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities could improve the overall salvage survival of fall-run Chinook Salmon.

On balance, given the small differences in the modeling results and the potential benefits anticipated by actions not captured in the models, it is concluded that effects on fall-run Chinook Salmon under Alternative 5 and Second Basis of Comparison would be similar.

Steelhead

Changes in operations that influence temperature and flow conditions in the Stanislaus River downstream of Goodwin Dam and the San Joaquin River below Vernalis could affect steelhead. The following describes those changes and their potential effects.

Changes in Water Temperature (Stanislaus River)

Average monthly water temperatures in the Stanislaus River at Goodwin Dam under Alternative 5 and Second Basis of Comparison generally would be similar (differences less than 0.5°F), except in August through October when long-term average monthly temperatures could be up to 1.0°F warmer than under the Second Basis of Comparison. These differences would be of higher magnitude in drier years with average monthly water temperatures in September as much as 1.9°F warmer under Alternative 5 as compared to the Second Basis of Comparison.

Downstream at Orange Blossom Bridge, average monthly water temperatures in October and April under Alternative 5 would be lower in all water year types than the Second Basis of Comparison by as much as 1.4°F in October and 1.6°F in April. In most other months, long-term average monthly water temperatures under Alternative 5 generally would be similar to water temperatures under the Second Basis of Comparison. Water temperatures under Alternative 5 could be up to 1.3°F warmer in drier years from July to September than under the Second Basis of Comparison. (Appendix 6B, Table B-18-6).

Downstream at the confluence with the San Joaquin River, average monthly water temperatures in October, April and May would be lower by 2.0°F in October, 1.9°F in April and 0.6°F in May. Differences in water temperatures between

Alternative 5 and the Second Basis of Comparison would be even greater in these months in some water year types. In most other months, long-term average monthly water temperatures under Alternative 5 generally would be similar, but could be somewhat higher (up to 1.1°F) in June, compared to the Second Basis of Comparison.

Changes in Exceedance of Water Temperature Thresholds (Stanislaus River)

Average monthly water temperatures in the Stanislaus River at Orange Blossom Bridge would frequently exceed the temperature threshold (56°F) established for adult steelhead migration under both Alternative 5 and Second Basis of Comparison during October and November. Under Alternative 5, average monthly water temperatures would exceed 56°F about 57 percent of the time in October which is about 28 percent less frequently than under the Second Basis of Comparison (Appendix 6B, Figure B-18-1). In November, average monthly water temperatures would exceed 56°F about 33 percent of the time under Alternative 5, which would be about 10 percent more frequently than under the Second Basis of Comparison.

In January through May, the temperature threshold at Orange Blossom Bridge is 55°F, which is intended to support steelhead spawning. This threshold would not be exceeded under either Alternative 5 or Second Basis of Comparison during January or February. In March through May, however, exceedances would occur under both Alternative 5 and the Second Basis of Comparison in each month, with the threshold most frequently exceeded (40 percent) under Alternative 5 in May (Appendix 9N). Average monthly water temperatures under Alternative 5 would exceed the threshold 4 percent more frequently in March 26 percent less frequently in April and 5 percent less frequently in May than under the Second Basis of Comparison.

From June through November, the temperature threshold of 65°F established to support steelhead rearing would be exceeded by both Alternative 5 and Second Basis of Comparison in all months but November. The differences between Alternative 5 and Second Basis of Comparison, however, would be small, with average monthly water temperatures under Alternative 5 generally exceeding the threshold by 3 percent to 8 percent more frequently than under the Second Basis of Comparison.

Average monthly water temperatures also would exceed the threshold (52°F) established for smoltification at Knights Ferry. At Goodwin Dam, about 4 miles upstream of Knights Ferry, average monthly water temperatures under Alternative 5 would exceed 52°F in March, April, and May about 8 percent, 37 percent, and 68 percent of the time, respectively. Alternative 5 would result in exceedances of the smoltification threshold occurring up to 6 percent more frequently during the January through May period. Farther downstream at Orange Blossom Bridge, the temperature threshold for smoltification is higher (57°F) and would be exceeded less frequently. The magnitude of the exceedance also would be less. Average monthly water temperatures under Alternative 5 and the Second

Basis of Comparison would not exceed the threshold during January through April. In May, the threshold would be exceeded 8 percent of the time under Alternative 5. Compared to the Second Basis of Comparison, the 57°F at Orange Blossom Bridge would be exceeded about 8 percent less frequently in April and 6 percent less frequently in May under Alternative 5.

Overall, the temperature differences between Alternative 5 and Second Basis of Comparison would be relatively small, with the exception of substantial differences in the frequency of exceedances in October when the average monthly water temperatures under Alternative 5 would exceed the threshold for adult steelhead migration about 28 percent less frequently and in April during the spawning period when the frequency would be about 26 percent less. Given the frequency of exceedance under both Alternative 5 and Second Basis of Comparison and the generally stressful temperature conditions in the river, the substantial differences (improvements) in October and April under Alternative 5 suggest that there would be less potential to result in adverse effects on steelhead under Alternative 5 than under the Second Basis of Comparison. Even during months when the differences would be relatively small, the lower frequency of exceedances under Alternative 5 suggest that there would be less potential to result in adverse effects on steelhead under Alternative 5 than under the Second Basis of Comparison.

Changes in Delta Hydrodynamics

Stanislaus River-origin steelhead generally move through the Delta during spring however there is less information on their timing relative to Chinook salmon. Thus, hydrodynamics in the entire January through June period have the potential to affect juvenile steelhead.

On the San Joaquin River near the Mokelumne River confluence, the median proportion of positive velocities was slightly greater under Alternative 5 relative to Second Basis of Comparison in January, February, April and May and similar in March and June. In Old River downstream of the facilities, the median proportion of positive velocities was substantially higher under Alternative 5 during January, April, and May and moderately higher in February. Values in March and June were almost indistinguishable between scenarios. On Old River upstream of the facilities, the median proportion of positive velocities was moderately lower in January and February, slightly lower in March and June, and slightly higher in April and May under Alternative 5 relative to Second Basis of Comparison. On the San Joaquin River downstream of Head of Old River, the median proportion of positive velocities was similar for both scenarios in January, February, March, and June, but slightly to moderately lower in April and May.

Summary of Effects on Steelhead

The analysis of the effects of the No Action Alternative and Second Basis of Comparison for steelhead relied on the water temperature model output for the rivers at various locations downstream of Goodwin Dam. Given the frequency of exceedance under both Alternative 5 and Second Basis of Comparison and the generally stressful temperature conditions in the river, the substantial differences (improvements) in October and April under Alternative 5 suggest that there would be less potential to result in adverse effects on steelhead under Alternative 5 than under the Second Basis of Comparison.

Implementation of a fish passage program under Alternative 5 intended to address the limited availability of suitable habitat for steelhead in the Stanislaus River reaches downstream of Goodwin Dam could provide a benefit to steelhead, however, the extent of benefit is uncertain. In addition, the potential effects of Alternative 5 could be offset by actions intended to reduce predation risk on steelhead in the Stanislaus River and increase the efficiency of the Tracy and Skinner Fish Collection Facilities. The actions to augment spawning gravel in the Stanislaus River under Alternative 5 also could benefit steelhead.

The numerical model results for effects on steelhead under Alternative 5 and Second Basis of Comparison do not definitively show distinct differences. However, in consideration of the potentially beneficial effects resulting from the actions that would be implemented under Alternative 5 that are not included in the numerical models (see Appendix 5A, Section B), Alternative 5 has a much greater potential to address the long-term sustainability of steelhead than does the Second Basis of Comparison. Alternative 5 includes provisions for fish passage upstream of New Melones Dam to address long-term temperature increases associated with climate change. Even though the success of fish passage is uncertain, it is concluded that the potential for adverse effects on steelhead under Alternative 5 would clearly be less than that under the Second Basis of Comparison, principally because the Second Basis of Comparison does not include a strategy to address water temperatures critical to steelhead sustainability over the long term with climate change by 2030.

White Sturgeon

Evidence of White Sturgeon spawning has been recorded in the San Joaquin River upstream of the confluence with the Stanislaus River. While flows in the San Joaquin River upstream of the Stanislaus River are expected be similar under all alternatives, flow contributions from the Stanislaus River could influence water temperatures in the San Joaquin River where White Sturgeon eggs or larvae may occur during the spring and early summer. The magnitude of influence on water temperature would depend on the proportional flow contribution of the Stanislaus River and the temperatures in both the Stanislaus and San Joaquin rivers. The potential for an effect on White Sturgeon eggs and larvae would be influenced by the proportion of the population occurring in the San Joaquin River. In consideration of this uncertainty, it is not possible to distinguish potential effects on White Sturgeon between alternatives.

Reservoir Fishes

As described in Chapter 5, Surface Water Resources and Water Supplies, changes in CVP and SWP water supplies and operations under Alternative 5 as compared to the Second Basis of Comparison would result in lower Storage levels in New Melones Reservoir under Alternative 5 as compared to the Second Basis of

Comparison due to increased instream releases to support fish flows under the 2009 NMFS BO.

Storage levels in New Melones Reservoir would be lower under Alternative 5 as compared to the Second Basis of Comparison (Appendix 5A), especially in critical years when the difference could be as much as 23 percent. Using storage volume as an indicator of available availability for fish species inhabiting these reservoirs, these results suggest that the amount of habitat for reservoir fishes could be decreased under Alternative 5 as compared to the Second Basis of Comparison. However, it is anticipated that aquatic habitat within the CVP and SWP water supply reservoirs is not limiting, such that this potential reduction in habitat may have little adverse effect on reservoir fishes.

Nest survival for black bass species in New Melones is higher than in the other reservoirs during May and June. For March, Largemouth Bass and Smallmouth Bass nest survival is predicted to be above 40 percent in all of the years simulated. For April, the likelihood that nest survival of Largemouth Bass and Smallmouth Bass is between 40 and 100 percent is substantially less (about 25 percent) under Alternative 5 as compared to the Second Basis of Comparison. For May, the likelihood of high nest survival is similar under Alternative 5 and the Second Basis of Comparison. For June, the likelihood of survival being greater than 40 percent for Largemouth Bass and Smallmouth Bass in New Melones is somewhat (about 10 percent) higher under Alternative 5 as compared to the Second Basis of Comparison. For Spotted Bass, nest survival in March is anticipated to be near 100 percent in every year under both Alternative 5 and Second Basis of Comparison. The likelihood of survival being greater than 40 percent is about 6 percent lower in April under Alternative 5 than under the Second Basis of Comparison, but is still reasonably high (about 90 percent). For May, the likelihood of high Spotted Bass nest survival is similar under Alternative 5 and the Second Basis of Comparison. For June, Spotted Bass nest survival would be greater than 40 percent in all of the simulation years under both Alternative 5 and the Second Basis of Comparison. Overall, the analysis suggests that conditions under Alternative 5 have the potential to influence black bass nesting success, especially in April and May in comparison to the Second Basis of Comparison. However, nesting success under Alternative 5 would still exceed 40 percent most of the time under both alternatives. Therefore, it is concluded that there would be no definitive difference in effects on reservoir fish between Alternative 5 and the Second Basis of Comparison.

Other species

Changes in operations that influence temperature and flow conditions in the Stanislaus River downstream of Keswick Dam and the San Joaquin River at Vernalis could affect other species such as lampreys, Hardhead, and Striped Bass.

As described above, average monthly water temperatures in the Stanislaus River at Goodwin Dam under Alternative 5 and Second Basis of Comparison generally would be similar (differences less than 0.5°F), except in August through October when long-term average monthly temperatures could be up to 1.0°F warmer than under the Second Basis of Comparison. These differences would be of higher magnitude in drier years with average monthly water temperatures in September as much as 1.9°F warmer under Alternative 5 as compared to the Second Basis of Comparison.

Downstream at Orange Blossom Bridge, average monthly water temperatures in October and April under Alternative 5 would be lower in all water year types than the Second Basis of Comparison by as much as 1.4°F in October and 1.6°F in April. In most other months, long-term average monthly water temperatures under Alternative 5 generally would be similar to water temperatures under the Second Basis of Comparison. Water temperatures under Alternative 5 could be up to 1.3°F warmer in drier years from July to September than under the Second Basis of Comparison (Appendix 6B, Table B-18-6).

Downstream at the confluence with the San Joaquin River, average monthly water temperatures in October, April and May would be lower by 2.0°F in October, 1.9°F in April and 0.6°F in May. Differences in water temperatures between Alternative 5 and the Second Basis of Comparison would be even greater in these months in some water year types. In most other months, long-term average monthly water temperatures under Alternative 5 generally would be similar, but could be somewhat higher (up to 1.1°F) in June, compared to the Second Basis of Comparison.

In general, lamprey species can tolerate higher temperatures than salmonids, up to around 72°F during their entire life history. Because lamprey ammocoetes remain in the river for several years, any substantial flow reductions or temperature increases could adversely affect larval lamprey. Given the similar flows and temperatures during their spawning and incubation period, it is likely that the potential to affect lamprey species in the Stanislaus and San Joaquin rivers would be similar under Alternative 5 and the Second Basis of Comparison.

In general, Striped Bass and Hardhead also can tolerate higher temperatures than salmonids. Given the similar flows and temperatures during their spawning and incubation period, it is likely that the potential to affect Striped Bass and Hardhead in the Stanislaus and San Joaquin rivers would be similar under Alternative 5 and the Second Basis of Comparison.

San Francisco Bay Area Region

Killer Whale

As described above for the comparison of Alternative 1 to the No Action Alternative, it is unlikely that the Chinook Salmon prey base of killer whales, supported heavily by hatchery production of fall-run Chinook Salmon, would be appreciably affected by any of the alternatives.

9.4.3.7 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 9.4 and 9.5, respectively.

Table 9.4 Comparison of Alternatives 1 through 5 to No Action Alternative

Alternative	Potential Change	Consideration for Mitigation Measures
Alternative 1	**Trinity River Region** Coho Salmon Overall, the temperature model outputs for each of the Coho Salmon life stages suggest that the temperature of water released at Lewiston Dam generally would be similar under both scenarios, although the exceedance of water temperature thresholds would be slightly less frequent (1 percent). Given the similarity of the results and the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), it is concluded that Alternative 1 and the No Action Alternative are likely to have similar effects on the Coho Salmon population in the Trinity River. Spring-run Chinook Salmon Although the water temperatures under Alternative 1 could result in adverse effects on spring-run Chinook Salmon in the Trinity River, these effects would not occur in every year and are not anticipated to be substantial based on the relatively small differences in water temperatures as compared to the No Action Alternative. However, implementation of the Hatchery Management Plan (RPA Action II.6.3) under the No Action Alternative could reduce the impacts of hatchery Chinook Salmon on natural spring-run Chinook Salmon in the Trinity River. Given the relatively minor changes in water temperature and water temperature threshold exceedance, the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), and the uncertainty of the hatchery benefits, Alternative 1 and the No Action Alternative are likely to have similar effects on spring-run Chinook Salmon in the Trinity River. Fall-run Chinook Salmon Although the combined analysis based on water temperature suggests that operations under Alternative 1 could be slightly less adverse than under the No Action Alternative, these effects would not occur in every year and are not anticipated to be substantial based on the relatively small differences in water temperatures (and similar egg mortality) between Alternative 1 and the No Action Alternative. In addition, the implementation of the Hatchery Management Plan (RPA Action II.6.3) under the No Action Alternative could reduce the impacts of hatchery Chinook Salmon on natural fall-run Chinook Salmon in the Trinity River. Overall, given the small differences in the numerical model results and the inherent uncertainty in the temperature model, as well as the potential for offsetting benefits associated with actions that were not modeled, it is concluded that Alternative 1 and the No Action Alternative are likely to have similar effects on the fall-run Chinook Salmon population in the Trinity River. Steelhead Although the analysis based on water temperature suggests that operations under Alternative 1 could be slightly less adverse than under the No Action Alternative, these effects would not occur in every year and are not anticipated to be substantial based on the relatively small differences in water temperatures between Alternative 1 and the No Action Alternative. Given these small differences in water temperatures and the inherent uncertainty in the temperature model,	Implement fish passage programs at Shasta, Folsom, and New Melones dams to reduce temperature impacts on Chinook Salmon and steelhead. Mitigation measures for other substantial impacts have not been identified at this time.

Alternative	Potential Change	Consideration for Mitigation Measures
	Alternative 1 and the No Action Alternative are likely to have similar effects on steelhead in the Trinity River. Green Sturgeon Overall, given the similarities between average monthly water temperatures at Lewiston Dam, it is likely that water temperature conditions for Green Sturgeon in the Trinity River or lower Klamath River and estuary would be similar under Alternative 1 and the No Action Alternative. Reservoir Fishes Overall, the comparison of storage and the analysis of nesting suggest that effects on reservoir fishes would be similar under Alternative 1 and the No Action Alternative. Pacific Lamprey On average, the temperature of water released at Lewiston Dam generally would be similar under Alternative 1 and the No Action Alternative. Given the similarities in water temperatures, it is likely that the effects on Pacific Lamprey would be similar. Eulachon Given that the highest increases in flow under Alternative 1 would be less than 10 percent in the Trinity River, with a smaller relative change in the lower Klamath River and Klamath River estuary, and that water temperatures in the Klamath River are unlikely to be affected by changes upstream at Lewiston Dam, it is likely that Alternative 1 would have a similar potential to influence Eulachon in the Klamath River as the No Action Alternative. **Sacramento River System** Winter-run Chinook Salmon Overall, the quantitative results from the numerical models suggest that operation under the Alternative 1 would be more likely to result in adverse effects on winter-run Chinook Salmon than would the No Action Alternative. In addition, the potentially beneficial effects resulting from the RPA actions under the No Action Alternative that are not included in the numerical suggest that the No Action Alternative has a much greater potential to address the long-term sustainability of winter-run Chinook Salmon than does the Alternative 1. It is concluded that the potential for adverse effects on winter-run Chinook Salmon under Alternative 1 would be greater than those under the No Action Alternative, principally because Alternative 1 does not include fish passage to address water temperatures critical to winter-run Chinook Salmon sustainability over the long term with climate change by 2030. Spring-run Chinook Salmon Overall, the quantitative results from the numerical models suggest that operation under Alternative 1 would be less likely to result in adverse effects on spring-run Chinook Salmon. However, it is concluded that the potential for adverse effects on spring-run Chinook Salmon under Alternative 1 would be greater, principally because Alternative 1 does not include fish passage to address water temperatures critical to spring-run Chinook Salmon sustainability over the long term with climate change by 2030	

Alternative	Potential Change	Consideration for Mitigation Measures
	Fall-run Chinook Salmon Overall, the quantitative results from the numerical models suggest that operation under Alternative 1 would be less likely to result in adverse effects on fall-run Chinook Salmon. This potential distinction between the two scenarios, however, may be partially balanced by the potentially beneficial effects resulting from the RPA actions evaluated qualitatively for the No Action Alternative. Given the small differences in the numerical model results and the inherent uncertainty in the temperature model, as well as the potential for benefits associated with the RPA actions under the No Action Alternative, it is likely that the effects on fall-run Chinook Salmon would be similar. Late Fall-run Chinook Salmon The output from SALMOD indicated that late fall-run Chinook Salmon production would be similar. The analyses attempting to assess the effects on routing, entrainment, and salvage of juvenile salmonids in the Delta suggest that salvage (as an indicator of potential losses of juvenile salmon at the export facilities) of Sacramento River-origin Chinook Salmon is predicted to be higher under Alternative 1 in every month. Although survival in the Delta may be lower, given the similarity in the SALMOD outputs, it is likely that the effects on late fall-run Chinook Salmon would be similar. Steelhead The numerical model results suggest that overall, effects on steelhead could be slightly less adverse, particularly in the Feather River. However, Alternative 1 would not include fish passage and implementation of an HGMP for steelhead at the Nimbus Fish Hatchery that would occur under the No Action Alternative. Therefore, it is concluded that the adverse effects on steelhead under Alternative 1 would be greater than those under the No Action Alternative. Green Sturgeon Overall, the temperature model outputs suggest that thermal conditions and effects on Green Sturgeon generally would be slightly less adverse under Alternative 1. The analysis based on Delta outflows suggests that Alternative 1 provides lower mean (March to July) outflows which could result in weaker year classes of juvenile Green Sturgeon relative to the No Action Alternative. However, early life stage survival in the natal rivers is crucial in development of a strong year class. Therefore, based primarily on the analysis of water temperatures, Alternative 1 could be less likely to result in adverse effects on Green Sturgeon than the No Action Alternative. White Sturgeon Overall, the temperature model outputs suggest that thermal conditions and effects on White Sturgeon generally would be slightly less adverse under Alternative 1. The analysis based on Delta outflows suggests that Alternative 1 provides lower mean (March to July) outflows which could result in weaker year classes of juvenile White Sturgeon relative to the No Action Alternative. However, early life stage survival in the natal rivers is crucial in development of a strong year class. Therefore, based primarily on the analysis of water temperatures, Alternative 1 could be less likely to result in adverse effects on White Sturgeon than the No Action Alternative.	

Alternative	Potential Change	Consideration for Mitigation Measures
	Delta Smelt Overall, Alternative 1 is likely to result in increased adverse effects on Delta Smelt primarily due to the potential for increased percentage entrainment during larval and juvenile life stages, and less favorable location of Fall X2 in wetter years, and on average. Given the current condition of the Delta Smelt population, even these small differences between Alternative 1 and the No Action Alternative may be important. Longfin Smelt Overall, based on the increase in frequency and magnitude of negative OMR flows and the lower Longfin Smelt abundance index values, especially in dry and critical dry years, potential adverse effects on the Longfin Smelt population likely would be greater. Sacramento Splittail Given the relatively minor changes in flows into the Yolo Bypass, and the inherent uncertainty associated with the resolution of the CalSim II model (average monthly outputs), it is concluded that there would be no definitive difference in effects on Sacramento Splittail between Alternative 1 and the No Action Alternative. Reservoir Fishes The analysis of black bass nest survival based on changes in water surface elevation during the spawning period indicated that the likelihood of high (>40 percent) nest survival in most of the reservoirs would be similar in March, April, and May under Alternative 1 would be similar to or slightly lower than under and the No Action Alternative, but somewhat lower in June. Most black bass spawning likely occurs prior to June, such that drawdowns during June would likely affect only a small proportion of the spawning population. Thus, it is concluded that effects on black bass nesting success would be similar under Alternative 1 and the No Action Alternative. Pacific Lamprey Based on the similar water temperatures during their spawning and incubation period, it likely that conditions for and effects on Pacific Lamprey in the Sacramento, Feather, and American rivers would be similar. This conclusion likely applies to other species of lamprey that inhabit these rivers (e.g., River Lamprey). Striped Bass, American Shad, and Hardhead In general, Striped Bass, American Shad, and Hardhead can tolerate higher temperatures than salmonids. Based on the similar water temperatures during their spawning and incubation period, it is likely that thermal conditions for and effects on Striped Bass, American Shad, and Hardhead in the Sacramento, Feather, and American rivers would be similar. Overall, however, Alternative 1 likely would have slightly greater potential for adverse effects on Striped Bass and American Shad as compared to the No Action Alternative, primarily due to the potential for reduced survival during larval and juvenile life stages, and less favorable location of Spring X2 on average. **Stanislaus River/Lower San Joaquin River** Fall-run Chinook Salmon Overall, the quantitative results from the numerical models suggest that operation under Alternative 1 would be less likely to result in adverse effects on fall-	

Alternative	Potential Change	Consideration for Mitigation Measures
	run Chinook Salmon. This potential distinction between the two scenarios, however, may be partially balanced by the potentially beneficial effects resulting from the RPA actions evaluated qualitatively for the No Action Alternative. Given the small differences in the numerical model results and the inherent uncertainty in the temperature model, as well as the potential for benefits associated with the RPA actions under the No Action Alternative, there would be no definitive difference in effects on fall-run Chinook Salmon between Alternative 1 and the No Action Alternative. Steelhead The temperature model outputs suggest that the differences in the magnitude and frequency of exceedance of suitable temperatures for the various lifestages have the potential for adverse effects on the steelhead populations in the Stanislaus River under Alternative 1. However, the magnitude of this effect is uncertain. It is concluded that the potential for adverse effects on steelhead would be greater, principally because Alternative 1 does not include fish passage to address water temperatures critical to steelhead sustainability over the long term with climate change by 2030. White Sturgeon While flows in the San Joaquin River upstream of the Stanislaus River are expected be similar, flow contributions from the Stanislaus River could influence water temperatures in the San Joaquin River where White Sturgeon eggs or larvae may occur during the spring and early summer. The magnitude of influence on water temperature would depend on the proportional flow contribution of the Stanislaus River and the temperatures in both the Stanislaus and San Joaquin rivers. The potential for an effect on White Sturgeon eggs and larvae would be influenced by the proportion of the population occurring in the San Joaquin River. In consideration of this uncertainty, it is not possible to distinguish potential effects on White Sturgeon between alternatives. Reservoir Fishes Overall, predicted nest survival is generally above 40 percent in all months evaluated, although survival would vary among months. In June, the likelihood of survival being greater than 40 percent is lower under Alternative 1. Most black bass spawning likely occurs prior to June, such that drawdowns during June would likely affect only a small proportion of the spawning population. Thus, effects on black bass nesting success would be similar. Other Species In general, lamprey species can tolerate higher temperatures than salmonids, up to around 72°F during their entire life history. Given the similar temperatures during their spawning and incubation period, it is likely that the potential to affect lamprey species in the Stanislaus and San Joaquin rivers would be similar. In general, Striped Bass and Hardhead also can tolerate higher temperatures than salmonids. Given the similar temperatures during their spawning and incubation period, it is likely that the potential to affect Striped Bass and Hardhead in the Stanislaus and San Joaquin rivers would be similar.	

Alternative	Potential Change	Consideration for Mitigation Measures
	Pacific Ocean Killer Whale Given conclusions from NMFS (2009c), and the fact that at approximately 75 percent of fall-run Chinook Salmon available for Southern Residents are produced by Central Valley hatcheries, it is likely that Central Valley fall-run Chinook Salmon as a prey base for killer whales would not be appreciably affected.	
Alternative 2	**Trinity River Region** Coho Salmon, spring-run and fall-run Chinook Salmon, steelhead, Green Sturgeon, Reservoir Fishes, Pacific Lamprey, River Lamprey, and Eulachon Similar effects. **Sacramento River System** Winter-run, spring-run, fall-run, and late fall-run Chinook Salmon, and steelhead The effects under Alternative 2 may become more adverse due to the lack of fish passage and other actions, such as structural improvements for temperature control on the American River; gravel augmentation, floodplain restoration and pulse flows, in Clear Creek; and measures to increase the efficiency of the Tracy and Skinner Fish Collection Facilities. Thus, it is concluded that the potential for adverse effects on salmonids and sturgeon under Alternative 2 would be greater than under the No Action Alternative. Green Sturgeon, White Sturgeon, Delta Smelt, Longfin Smelt, Sacramento Splittail, Reservoir Fishes, Pacific Lamprey, River Lamprey, Striped Bass, American Shad, and Hardhead Similar effects. **Stanislaus River/Lower San Joaquin River** Fall-run Chinook Salmon and Steelhead The effects under Alternative 2 may become more pronounced due to the lack of fish passage and other actions that would occur under the No Action Alternative such as gravel augmentation, floodplain restoration and inundation flows, and freshwater migratory habitat restoration in the Stanislaus River; and measures to increase the efficiency of the Tracy and Skinner Fish Collection Facilities. White Sturgeon, Reservoir Fishes, and Other Species Similar effects. **Pacific Ocean** Killer Whale Similar effects.	Implement fish passage programs at Shasta, Folsom, and New Melones dams to reduce temperature impacts on Chinook Salmon and steelhead.
Alternative 3	**Trinity River Region** Coho Salmon and Spring-run Chinook Salmon Overall, the water temperature model outputs suggest that the temperature of water released at Lewiston Dam generally would be similar under both scenarios, although the exceedance of water temperature thresholds would be less frequent (by 1 to 2 percent) under Alternative 3. Given the similarity of the results and the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), it is concluded that Alternative 3 and the No Action Alternative are likely to have similar effects on the Coho Salmon population in the Trinity River. This conclusion also applies to spring-run Chinook Salmon,	Implement fish passage programs at Shasta, Folsom, and New Melones dams to reduce temperature impacts on Chinook Salmon and steelhead. Mitigation measures for other substantial impacts have not been identified at this time.

Alternative	Potential Change	Consideration for Mitigation Measures
	although the implementation of the Hatchery Management Plan (RPA Action II.6.3) under the No Action Alternative could reduce the impacts of hatchery Chinook Salmon on natural spring-run Chinook Salmon in the Trinity River, and increase the genetic diversity and diversity of run-timing for these stocks relative to Alternative 3. <u>Fall-run Chinook Salmon</u> Overall, the temperature model outputs suggest that the temperature of water released at Lewiston Dam generally would be similar under both scenarios, although the exceedance of water temperature thresholds would be less frequent (by up to 2 percent) under Alternative 3. Given the similarity of the results and the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), Alternative 3 is likely to have similar effects on the fall-run Chinook Salmon population in the Trinity River as compared to the No Action Alternative. However, the implementation of the Hatchery Management Plan (RPA Action II.6.3) under the No Action Alternative could reduce the impacts of hatchery Chinook Salmon on natural fall-run Chinook Salmon in the Trinity River, and increase the genetic diversity and diversity of run-timing for these stocks relative to Alternative 3. <u>Steelhead</u> Overall, the differences in the frequency of threshold exceedance between Alternative 3 and the No Action Alternative would be relatively minor and are unlikely to affect steelhead spawning in the Trinity River. This slight reduction in the frequency of threshold exceedance provided by Alternative 3 suggest that temperature conditions under Alternative 3 could be slightly less likely to affect steelhead than under the No Action Alternative. However, the relatively small differences in flows and water temperatures under Alternative 3 as compared to the No Action Alternative would likely have similar effects on steelhead in the Trinity River as compared to the No Action Alternative. <u>Green Sturgeon</u> Given the similarities between average monthly water temperatures at Lewiston Dam, it is likely that water temperature conditions for Green Sturgeon in the Trinity River or lower Klamath River and estuary would be similar. <u>Reservoir Fishes</u> Overall, while reservoir storage and nest survival would be slightly higher under Alternative 3, it is uncertain whether these differences would be biologically meaningful. Thus, it is concluded that effects on black bass likely would be similar for Alternative 3 and the No Action Alternative. <u>Pacific Lamprey</u> Overall, it is likely that effects on Pacific Lamprey would be similar. This conclusion likely also applies to other species of lamprey that inhabit the Trinity and lower Klamath rivers (e.g., River Lamprey). <u>Eulachon</u> Given that the highest increases in flow would be less than 10 percent in the Trinity River, with a smaller relative increase in the lower Klamath River and	

Alternative	Potential Change	Consideration for Mitigation Measures
	Klamath River estuary, and that water temperatures in the Klamath River would unlikely to be affected by changes upstream at Lewiston Dam, it is likely that effects would have a similar potential to influence Eulachon in the Klamath River. **Sacramento River System** Winter-run Chinook Salmon Overall, given the small differences between alternatives and the uncertainty regarding the non-operational components, distinguishing a clear difference between alternatives is difficult. The non-operational components associated with Alternative 3 could benefit winter-run Chinook Salmon over the short term if successful. However, these measures would not address the long-term temperature challenges in the river downstream of Shasta Dam that would be addressed under the No Action Alternative. It is concluded that the potential for adverse effects on winter-run Chinook Salmon under Alternative 3 would be greater, principally because Alternative 3 does not include a strategy to address water temperatures critical to winter-run Chinook Salmon sustainability over the long term. Spring-run Chinook Salmon The model results suggest that overall, effects on spring-run Chinook Salmon could be slightly more adverse. However, the ocean harvest restriction component and predator control measures could reduce spring-run Chinook Salmon mortality. These non-operational components could benefit spring-run Chinook Salmon over the short term if successful. However, these measures would not address the long-term temperature challenges in the river downstream of Shasta Dam that would be addressed through fish passage under the No Action Alternative. It is concluded that the potential for adverse effects on spring-run Chinook Salmon under Alternative 3 would be greater, principally because Alternative 3 does not include a strategy to address water temperatures critical to spring-run Chinook Salmon sustainability over the long term. Fall-run Chinook Salmon Overall, the results of the numerical models suggest the potential for less adverse effects on fall-run Chinook Salmon. However, discerning a meaningful difference between these two scenarios based on the quantitative results is not possible because of the similarity in results (generally differences less than 5 percent) and the inherent uncertainty of the models. Adverse effects of Alternative 3 could be offset by the potentially beneficial effects resulting from predator control and ocean harvest restrictions. However, Alternative 3 does not contain the RPA actions that could provide benefit under the No Action Alternative. Thus, effects on fall-run Chinook Salmon would be similar. Late Fall-run Chinook Salmon Overall, the results of the numerical models suggest that potential effects on late fall-run Chinook Salmon would be similar. Discerning a meaningful difference between these two scenarios based on the quantitative results is not possible because of the similarity in results (generally differences less than 5 percent) and the inherent uncertainty of the models. Because fish passage under the No Action Alternative is not expected	

Alternative	Potential Change	Consideration for Mitigation Measures
	to directly benefit late fall-run Chinook Salmon, the non-operational actions intended to benefit salmonids under both alternatives are expected to balance. Thus, it is concluded that the effects on late fall-run Chinook Salmon would be similar under Alternative 3 and the No Action Alternative. Steelhead The model results suggest that overall, effects on steelhead could be slightly less adverse, particularly in the Feather River. The ocean harvest restriction component and predator control measures could reduce steelhead mortality. This potential distinction may be partially offset and become more adverse by the lack of the benefits of implementation of fish passage. This is particularly important in light of anticipated increases in water temperature associated with climate change in 2030. Thus, on balance and over the long term, the adverse effects on steelhead under Alternative 3 would be greater than those under the No Action Alternative. Green Sturgeon The temperature model outputs suggest that thermal conditions and effects on Green Sturgeon in the Sacramento and Feather rivers generally would be slightly less adverse under Alternative 3. By contrast, the analysis based on Delta outflows suggests that Alternative 3 provides lower mean (March to July) outflows which could result in weaker year classes of juvenile sturgeon. However, early life stage survival in the natal rivers is crucial in development of a strong year class, and actions under the No Action Alternative intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities could improve the overall salvage survival of green sturgeon. Therefore, based primarily on the analysis of water temperatures, adverse effects on Green Sturgeon would be less likely. White Sturgeon Given the general similarity in results and the inherent uncertainty associated with the resolution of the temperature model, the effects likely would be similar. However, the analysis based on Delta outflows suggests that Alternative 3 provides lower mean (March to July) outflows which could result in weaker year classes of juvenile sturgeon Overall, given the small differences in the numerical model results and the inherent uncertainty in the temperature model, as well as the potential for offsetting effects of increased Delta outflow and improved salvage survival under the No Action Alternative, there would be no definitive difference in effects on White Sturgeon. Delta Smelt Overall, likely would result in increased adverse effects, primarily due to increased percentage entrainment during larval and juvenile life stages, and less favorable location of Fall X2 in wetter years, and on average. Given the current condition of the Delta Smelt population, even these small differences between alternatives may be important. Longfin Smelt Overall, based on the increase in frequency and magnitude of negative OMR flows and the lower Longfin Smelt abundance index values, potential adverse effects likely would be greater.	

Alternative	Potential Change	Consideration for Mitigation Measures
	<u>Sacramento Splittail</u> Flows entering the Yolo Bypass generally would be somewhat higher than under the No Action Alternative from December through March, especially during wetter years, providing similar value to Sacramento Splittail because of the similar area of potential habitat (inundation). Given the relatively minor changes in flows into the Yolo Bypass, and the inherent uncertainty associated with the resolution of the CalSim II model (average monthly outputs), it is concluded that there would be no definitive difference in effects on Sacramento Splittail between Alternative 3 and the No Action Alternative. <u>Reservoir Fishes</u> The analysis of black bass nest survival based on changes in water surface elevation during the spawning period indicated that the likelihood of high (greater than 40 percent) nest survival in most of the reservoirs would be similar in March, April, and May, but somewhat lower in June. Most black bass spawning likely occurs prior to June, such that drawdowns during June would likely affect only a small proportion of the spawning population. Overall, the results of the habitat and nest survival analysis suggest that conditions in the reservoirs likely to support self-sustaining populations of black bass would be similar under Alternative 3 and the No Action Alternative. <u>Pacific Lamprey</u> Pacific Lamprey would be subjected to the same temperature conditions described above for salmonids. Based on the somewhat increased water temperatures from January through the summer, it is likely that there would be little difference in potential effects on Pacific Lamprey in the Sacramento, Feather, and American rivers This conclusion likely applies to other species of lamprey that inhabit these rivers (e.g., River Lamprey). <u>Other Species</u> Based on the similar water temperatures during their spawning and incubation period under Alternative 3, it is likely that thermal conditions for and effects on Striped Bass, American Shad, and Hardhead in the Sacramento, Feather, and American rivers would be similar under Alternative 1 and the No Action Alternative. Alternative 3 would result in a more eastward X2 position as compared to the No Action Alternative during April and May, with similar values in June (Appendix 5A, Section C Table C-16-2). Based on Kimmerer (2002) and Kimmerer et al. (2009), this change in X2 would likely reduce the survival index and the habitat index as measured by salinity for Striped Bass and abundance and habitat index for American Shad. In addition, the increased bag limits and ability of anglers to retain Striped Bass that are 12 inches in length versus 18 inches under Alternative 3 could reduce the ability to meet the doubling goals for Striped Bass populations under the requirements of Section 3406(b)(1) of CVPIA. Overall, Alternative 3 likely would have similar effects on Hardhead, but slightly greater potential for adverse effects on Striped Bass and American Shad as compared to the No Action Alternative, primarily due to the potential for reduced survival during larval and	

Alternative	Potential Change	Consideration for Mitigation Measures
	juvenile life stages, and less favorable location of Spring X2 on average. **Stanislaus River/Lower San Joaquin River** Fall-run Chinook Salmon Overall, likely would have similar effects on the fall-run Chinook Salmon population in the San Joaquin River watershed. Beneficial effects to juvenile fall-run Chinook Salmon could result from implementation of trap and haul passage through the Delta and ocean harvest restrictions. It remains uncertain, however, if predator management actions under Alternative 3 would benefit fall-run Chinook Salmon. Steelhead Given the frequency of exceedance under both Alternative 3 and the No Action Alternative, water temperature conditions for steelhead in the Stanislaus River would be generally stressful in the fall, late spring, and summer months. The differences in temperature exceedance between Alternative 3 and the No Action Alternative would be relatively small, with no clear benefit associated with either alternative. However, because Alternative 3 generally would exceed thresholds less frequently during the warmest months, it may have slightly less impact than under the No Action Alternative. Alternative 3 also could provide additional beneficial effects to juvenile steelhead as a result of trap and haul passage through the Delta. It remains uncertain, however, if predator management actions under Alternative 3 would benefit steelhead. This potential distinction between the two alternatives, however, may be partially offset by the benefits of implementation of fish passage under the No Action Alternative intended to address the limited availability of suitable habitat for in the Stanislaus River reaches downstream of New Melones Dam. In addition, RPA actions intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities could improve the overall salvage survival of steelhead under the No Action Alternative. Implementation of the fish passage program under the No Action could provide a benefit to Central Valley steelhead in the Stanislaus River. This is particularly important in light of anticipated increases in water temperature associated with climate change in 2030. In addition, RPA actions intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities could improve the overall salvage survival of steelhead under the No Action Alternative. Thus, it is concluded that the potential for adverse effects on steelhead would be greater, principally because Alternative 3 does not include a strategy to address water temperatures critical to steelhead sustainability over the long term with climate change by 2030. White Sturgeon While flows in the San Joaquin River upstream of the Stanislaus River are expected be similar, flow contributions from the Stanislaus River could influence water temperatures in the San Joaquin River where White Sturgeon eggs or larvae may occur during the spring and early summer. The magnitude of influence on water temperature would depend on the proportional flow contribution of the Stanislaus River and the temperatures in both the Stanislaus and San Joaquin	

Alternative	Potential Change	Consideration for Mitigation Measures
	rivers. The potential for an effect on White Sturgeon eggs and larvae would be influenced by the proportion of the population occurring in the San Joaquin River. In consideration of this uncertainty, it is not possible to distinguish potential effects on White Sturgeon. Reservoir Fishes While the analyses suggest that the effects could be more adverse, most black bass spawning likely occurs prior to June, such that drawdowns during June would likely affect only a small proportion of the spawning population. Thus, it is concluded that effects on black bass nesting success would be similar under Alternative 3 and the No Action Alternative. Other Species In general, lampreys, Striped Bass and Hardhead also can tolerate higher water temperatures than salmonids. Thus, temperature effects on these species are expected to be similar under both alternatives. Predator controls related to Striped Bass could result in adverse effects. **Pacific Ocean** Killer Whale It is unlikely that the Chinook Salmon prey base of killer whales, supported heavily by hatchery production of fall-run Chinook Salmon, would be appreciably affected.	
Alternative 4	**Trinity River Region** Coho Salmon, spring-run and fall-run Chinook Salmon, steelhead, Green Sturgeon, Reservoir Fishes, Pacific Lamprey, River Lamprey, and Eulachon The effects are identical as described under Alternative 1 as compared to the No Action Alternative. **Sacramento River System** Winter-run, spring-run, fall-run, and late fall-run Chinook Salmon, and steelhead 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 the effects in the Sacramento River system would be similar to those described under Alternative 1. Conditions related to salmonid survival could be improved under Alternative 4 by implementation of a trap and haul program, changes in Striped Bass bag limits, and changes in PMFC/NMFS harvest limits. However, these benefits would not likely exceed those described for the No Action Alternative, particularly in consideration of the provision of fish passage to address long-term temperature challenges on listed salmonids caused by climate change. Green Sturgeon, White Sturgeon, Delta Smelt, Longfin Smelt, Sacramento Splittail, Reservoir Fishes, Pacific Lamprey, River Lamprey, American Shad, and Hardhead The effects in the Sacramento River system would be similar to those described under Alternative 1. Striped Bass The effects in the Sacramento River system would be similar to those described under Alternative 1. Conditions for Striped Bass could be influenced by implementation of a predator control program that reduces the size restrictions and increases the catch	Implement fish passage programs at Shasta, Folsom, and New Melones dams to reduce temperature impacts on Chinook Salmon and steelhead. Mitigation measures for other substantial impacts have not been identified at this time.

Alternative	Potential Change	Consideration for Mitigation Measures
	limit for Striped Bass taken in the sport fishery. This also could reduce the ability to meet the doubling goals for Striped Bass populations under the requirements of Section 3406(b)(1) of CVPIA. **Stanislaus River/Lower San Joaquin River** Fall-run Chinook Salmon and Steelhead The effects in the Stanislaus River/Lower San Joaquin River system would be similar to those described under Alternative 1. Beneficial effects to Chinook Salmon as a result of trap and haul passage through the Delta and ocean harvest restrictions. It remains uncertain, however, if predator management actions would benefit the Chinook Salmon population. White Sturgeon, Reservoir Fishes, and Other Species The effects in the Stanislaus River/Lower San Joaquin River system would be similar to those described under Alternative 1. Striped Bass The effects in the Stanislaus River/Lower San Joaquin River system would be similar as described under Alternative 1 as compared to the No Action Alternative. Conditions for Striped Bass could be influenced by implementation of a predator control program that reduces the size restrictions and increases the catch limit for Striped Bass taken in the sport fishery. This also could reduce the ability to meet the doubling goals for Striped Bass populations under the requirements of Section 3406(b)(1) of CVPIA. **Pacific Ocean** Killer Whale It is unlikely that the Chinook Salmon prey base of killer whales, supported heavily by hatchery production of fall-run Chinook Salmon, would be appreciably affected.	
Alternative 5	**Trinity River Region** Coho Salmon, Spring-run Chinook Salmon, Fall-run Chinook Salmon, Steelhead, and Green Sturgeon Effects would be similar. Reservoir Fishes Effects would be similar. Pacific Lamprey Effects would be similar. Eulachon Effects would be similar. **Sacramento River System** Winter-run Chinook Salmon, Spring-run Chinook Salmon, Fall-run Chinook Salmon, Late Fall-run Chinook Salmon, Steelhead, Green Sturgeon, and White Sturgeon Effects would be similar. Delta Smelt, Longfin Smelt, and Sacramento Splittail Effects would be similar. Reservoir Fishes Effects would be similar. Pacific Lamprey and Other Species Effects would be similar.	Mitigation measures for other substantial impacts have not been identified at this time.

Alternative	Potential Change	Consideration for Mitigation Measures
	Stanislaus River/Lower San Joaquin River Fall-run Chinook Salmon and Steelhead The analysis of temperatures indicates somewhat higher temperatures in some water year types and a higher likelihood of exceedance of suitable temperatures for spawning, and lower likelihood of exceeding suitable temperature for rearing of fall-run Chinook Salmon. The frequency of exceedance of temperature thresholds for steelhead smoltification and rearing could be more stressful. However, the higher flows in April and May and lower temperatures in April and May could benefit steelhead spawning. Given the variability in the results and the inherent uncertainty associated with the resolution of the models, it is concluded that Alternative 5 is likely to have similar effects on fall-run Chinook Salmon and steelhead in the Stanislaus and lower San Joaquin rivers. White Sturgeon While flows in the San Joaquin River upstream of the Stanislaus River are expected be similar, flow contributions from the Stanislaus River could influence water temperatures in the San Joaquin River where White Sturgeon eggs or larvae may occur during the spring and early summer. The magnitude of influence on water temperature would depend on the proportional flow contribution of the Stanislaus River and the temperatures in both the Stanislaus and San Joaquin rivers. The potential for an effect on White Sturgeon eggs and larvae would be influenced by the proportion of the population occurring in the San Joaquin River. In consideration of this uncertainty, it is not possible to distinguish potential effects on White Sturgeon. Reservoir Fishes Overall, the analysis suggests that conditions under Alternative 5 have the potential to negatively influence black bass nesting success, especially in April and May. However, nesting success under Alternative 5 would still exceed 40 percent most of the time. Therefore, it is likely that the effects on black basses in New Melones Reservoir would be similar. Other Species Given the similar water temperatures, it is likely that the potential to affect lamprey species in the Stanislaus and San Joaquin rivers would be similar. Striped Bass and Hardhead also can tolerate higher temperatures than salmonids. Given the similar water temperatures, it is likely that the potential effects to affect Striped Bass and Hardhead in the Stanislaus and San Joaquin rivers would be similar **Pacific Ocean** Killer Whale It is unlikely that the Chinook Salmon prey base of killer whales, supported heavily by hatchery production of fall-run Chinook Salmon, would be appreciably affected.	

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 9.5 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** Coho Salmon Overall, the temperature model outputs for each of the Coho Salmon life stages suggest that the temperature of water released at Lewiston Dam generally would be similar, although the exceedance of water temperature thresholds would be slightly more frequent (1 percent). Given the similarity of the results and the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), it is concluded that the No Action Alternative and Second Basis of Comparison are likely to have similar effects on the Coho Salmon population in the Trinity River. Spring-run Chinook Salmon Overall, water temperature could have adverse effects on spring-run Chinook Salmon in the Trinity River; however, these effects would not occur in every year and are not anticipated to be substantial based on the relatively small differences in flows and water temperatures. However, the implementation of the Hatchery Management Plan could reduce the impacts of hatchery Chinook Salmon on natural spring-run Chinook Salmon in the Trinity River. Thus, given these relatively minor changes in temperature and temperature threshold exceedance, the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), and the uncertainty of the hatchery benefits, it is concluded that the No Action Alternative and Second Basis of Comparison are likely to have similar effects on the spring-run Chinook Salmon in the Trinity River. Fall-run Chinook Salmon Although the combined analysis based on water temperature suggests that operations could be slightly more adverse, these effects would not occur in every year and are not anticipated to be substantial based on the relatively small differences in water temperatures (as well as egg mortality). In addition, these potential adverse effects could be offset by implementation of the Hatchery Management Plan (RPA Action II.6.3), which could reduce the impacts of hatchery Chinook Salmon on natural fall-run Chinook Salmon in the Trinity River, and increase the genetic diversity and diversity of run-timing for these stocks. Overall, given the small differences in the numerical model results and the inherent uncertainty in the temperature model, as well as the potential for offsetting benefits associated with actions that were not modeled, it is concluded that the No Action Alternative is likely to have similar effects on the fall-run Chinook Salmon population in the Trinity River. Steelhead Although the combined analysis based on water temperature suggests that operations could be slightly more adverse, these effects would not occur in every year and are not anticipated to be substantial based on the relatively small differences in water temperature exceedances. Overall, given these small differences and the inherent uncertainty in the temperature model, these two scenarios are likely to have similar effects on the steelhead population in the Trinity River.	Not considered for this comparison.

Alternative	Potential Change	Consideration for Mitigation Measures
	<u>Green Sturgeon</u> Overall, given the similarities between average monthly water temperatures at Lewiston Dam, it is likely that temperature conditions for Green Sturgeon in the Trinity River or lower Klamath River and estuary would be similar. <u>Reservoir Fishes</u> Overall, the comparison of storage and the analysis of black bass nesting suggest that effects would be similar. <u>Pacific Lamprey</u> Overall, given the similarities between average monthly water temperatures at Lewiston Dam, it is likely that the effects would be similar. This conclusion likely applies to other species of lamprey that inhabit the Trinity and lower Klamath rivers (e.g., River Lamprey). <u>Eulachon</u> Given that the highest reductions in flow would be less than 10 percent in the Trinity River, which would represent even a smaller proportion in the lower Klamath River and Klamath River estuary, and that water temperatures in the Klamath River are unlikely to be affected by changes upstream at Lewiston Dam, it is likely the conditions would be similar for Eulachon in the Klamath River. **Sacramento River System** <u>Winter-run Chinook Salmon</u> Overall, the quantitative results from the numerical models suggest that the No Action Alternative would be less likely to result in adverse effects on winter-run Chinook Salmon. In consideration of the potentially beneficial effects resulting from the RPA actions that are not included in the numerical models, the No Action Alternative has a much greater potential to address the long-term sustainability of winter-run Chinook Salmon than does the Second Basis of Comparison, principally because the Second Basis of Comparison does not include a strategy to address water temperatures critical to winter-run Chinook Salmon sustainability over the long term with climate change by 2030. <u>Spring-run Chinook Salmon</u> The model results suggest that overall, effects on spring-run Chinook Salmon could be slightly more adverse with a small likelihood that spring-run Chinook Salmon production would be lower under the No Action Alternative. However, it is concluded that the potential for adverse effects on spring-run Chinook Salmon suggested by the results of the numerical models would likely be offset by the potential benefits of the RPA actions that are not included in the numerical models, principally because the Second Basis of Comparison does not include a strategy to address water temperatures critical to spring-run Chinook Salmon sustainability over the long term with climate change by 2030. On balance and over the long term, the adverse effects on spring-run Chinook Salmon would be less than those under the Second Basis of Comparison. <u>Fall-run Chinook Salmon</u> Overall, the results of the numerical models suggest the potential for greater adverse effects on fall-run Chinook Salmon under the No Action Alternative as compared to the Second Basis of Comparison. However, discerning a meaningful difference between these two scenarios based on the quantitative results is not possible	

Alternative	Potential Change	Consideration for Mitigation Measures
	because of the similarity in results and the inherent uncertainty of the models. In addition, any adverse effect of the No Action Alternative could be offset by the potentially beneficial effects resulting from the RPA actions evaluated qualitatively for the No Action Alternative. Thus, it is concluded that the effects on fall-run Chinook Salmon would be less adverse under the No Action Alternative than under the Second Basis of Comparison. Late Fall-run Chinook Salmon The model results suggest that overall, effects on late fall-run Chinook Salmon could be slightly less adverse. Potential effects may be lessened further due to actions intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities to improve the overall salvage survival of salmonids, including late fall-run Chinook Salmon. Thus, it is concluded that the potential for adverse effects on late fall-run Chinook Salmon would be lower under the No Action Alternative compared to the Second Basis of Comparison. Steelhead The numerical model results suggest that overall, effects on steelhead could be slightly more adverse, particularly in the Feather and American rivers. However, implementation of a fish passage program under the No Action Alternative intended to address the limited availability of suitable habitat for steelhead in the Sacramento River reaches downstream of Keswick Dam and in the American River could provide a benefit to Central Valley steelhead in the Sacramento and American rivers. This is particularly important in light of anticipated increases in water temperature associated with climate change in 2030. In addition to fish passage, preparation and implementation of an HGMP for steelhead at the Nimbus Fish Hatchery and actions under the No Action Alternative intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities could benefit steelhead under the No Action Alternative in comparison to the Second Basis of Comparison. Thus, it is concluded that the effects on steelhead would be less adverse under the No Action Alternative than under the Second Basis of Comparison. Green Sturgeon The increased frequency of exceedance of temperature thresholds under the No Action Alternative could increase the potential for adverse effects on Green Sturgeon in the Sacramento and Feather rivers relative to the Second Basis of Comparison. However, the analysis based on Delta outflows suggests that the No Action Alternative provides higher mean (March to July) outflows which could result in stronger year classes of juvenile Green Sturgeon relative to the Second Basis of Comparison. In addition, actions under the No Action Alternative intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities could improve the overall salvage survival of Green Sturgeon. However, early life stage survival in the natal rivers is crucial in development of a strong year class. In addition, actions under the No Action Alternative intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities could improve the overall salvage survival of green sturgeon. Therefore, based primarily on the analysis of water temperatures, the No Action Alternative could be more	

Alternative	Potential Change	Consideration for Mitigation Measures
	likely to result in adverse effects on Green Sturgeon than the Second Basis of Comparison. White Sturgeon Overall, the increased frequency of exceedance of temperature thresholds in June under the No Action Alternative could increase the potential for effects on White Sturgeon in the Sacramento River relative to the Second Basis of Comparison, however, these effects are uncertain and may include reduced spawning and/or increased growth. The analysis based on Delta outflows suggests that the No Action Alternative provides higher mean (March to July) outflows which could result in stronger year classes of juvenile White Sturgeon relative to the Second Basis of Comparison. However, early life stage survival in the natal rivers is crucial in development of a strong year class. Therefore, based primarily on the analysis of water temperatures, the No Action Alternative could be more likely to result in adverse effects on White Sturgeon than the Second Basis of Comparison. Delta Smelt Overall, likely to result in better conditions for Delta Smelt, primarily due to lower percentage entrainment for larval and juvenile life stages, and more favorable location of Fall X2 in wetter years, and on average. Given the current condition of the Delta Smelt population, even these small differences between alternatives may be important. Longfin Smelt Overall, based on the decrease in frequency and magnitude of negative OMR flows and the higher Longfin Smelt abundance index values, especially in dry and critical dry years, potential adverse effects on the Longfin Smelt population likely would be less. Sacramento Splittail Overall, the slight flow decreases under the No Action Alternative could result in less spawning habitat for Sacramento Splittail than under the Second Basis of Comparison because of the decreased area of potential habitat (inundation). Given the relatively minor changes in flows into the Yolo Bypass and the inherent uncertainty associated with the resolution of the CalSim II model (average monthly outputs), it is concluded that there would be no definitive difference in effects on Sacramento Splittail between the No Action Alternative and Second Basis of Comparison. Reservoir Fishes The analysis of black bass nest survival based on changes in water surface elevation during the spawning period indicated that the likelihood of high (greater than 40 percent) nest survival in most of the reservoirs would be similar from March through May and somewhat higher in June. Most black bass spawning likely occurs prior to June, such that drawdowns during June would likely affect only a small proportion of the spawning population. Thus, it is concluded that effects on black bass nesting success would be similar under the No Action Alternative and the Second Basis of Comparison. Pacific Lamprey Given the relatively minor changes in water temperature and water temperature threshold exceedance, and the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), it is	

Alternative	Potential Change	Consideration for Mitigation Measures
	likely that effects on Pacific Lamprey in the Sacramento, Feather, and American rivers would be similar. This conclusion likely applies to other species of lamprey that inhabit these rivers (e.g., River Lamprey). Striped Bass, American Shad, and Hardhead In general, Striped Bass, American Shad, and Hardhead can tolerate higher temperatures than salmonids. Given the relatively minor changes in temperature and temperature threshold exceedance, and the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), it is likely that conditions for and effects on Striped Bass, American Shad, and Hardhead in the Sacramento, Feather, and American rivers would be similar. Overall, the No Action Alternative likely would be similar for Hardhead and have a slightly lower potential for adverse effects on Striped Bass and American Shad as compared to the Second Basis of Comparison, primarily due to the potential for increased survival during larval and juvenile life stages, and more favorable location of Spring X2 on average. **Stanislaus River/Lower San Joaquin River** Fall-run Chinook Salmon The water temperature model outputs for each of the life stages suggest that thermal conditions and effects on fall-run Chinook Salmon in the Stanislaus River generally would be similar, although water temperatures under the No Action Alternative could be somewhat more suitable for fall-run Chinook Salmon spawning/egg incubation. Because the No Action Alternative has the potential for beneficial effects resulting from the RPA actions, it is concluded that the effects on fall-run Chinook Salmon would be less adverse relative to the Second Basis of Comparison. Steelhead The water temperature model outputs suggest that the differences in the magnitude and frequency of exceedance of suitable temperatures for the various lifestages could have the potential for adverse effects on steelhead in the Stanislaus River. However, the direction and magnitude of this effect is uncertain. It is concluded that the potential for adverse effects on steelhead would be lower, principally because the Second Basis of Comparison does not include a strategy to address water temperatures critical to steelhead sustainability over the long term with climate change by 2030. White Sturgeon Evidence of White Sturgeon spawning has been recorded in the San Joaquin River upstream of the confluence with the Stanislaus River. While flows in the San Joaquin River upstream of the Stanislaus River are expected be similar under all alternatives, flow contributions from the Stanislaus River could influence water temperatures in the San Joaquin River where White Sturgeon eggs or larvae may occur during the spring and early summer. The magnitude of influence on water temperature would depend on the proportional flow contribution of the Stanislaus River and the temperatures in both the Stanislaus and San Joaquin rivers. The potential for an effect on White Sturgeon eggs and larvae would be influenced by the proportion of the population occurring in the San Joaquin River. In consideration of this uncertainty, it is not possible to	

Alternative	Potential Change	Consideration for Mitigation Measures
	distinguish potential effects on White Sturgeon between alternatives. Reservoir Fishes Overall, predicted nest survival is generally above 40 percent in all months evaluated, although survival would vary among months. Given the relatively high survival in general and the uncertainty caused by the inconsistency in changes in survival, it is likely that effects would be similar. Other Species In general, Pacific Lamprey, Striped Bass, and Hardhead also can tolerate higher temperatures than salmonids. Given the relatively minor changes in temperature and temperature threshold exceedance, the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), it is likely that the potential to affect these species in the Stanislaus and San Joaquin rivers would be similar. **Pacific Ocean** Killer Whale Given conclusions from NMFS (2009c), and the fact that at least 75 percent of fall-run Chinook Salmon available for Southern Residents are produced by Central Valley hatcheries, it is likely that Central Valley fall-run Chinook Salmon as a prey base for killer whales would not be appreciably affected.	
Alternative 1	No effects on aquatic resources.	Not considered for this comparison.
Alternative 2	**Trinity River Region** The effects are identical as described under the No Action Alternative as compared to the Second Basis of Comparison. **Sacramento River System** The CVP and SWP operations under Alternative 2 are identical to the CVP and SWP operations under the No Action Alternative. Therefore, changes in physical conditions that affect aquatic resources in the Central Valley Region would be the same as the impacts described for the No Action Alternative Compared to the Second Basis of Comparison. However, actions to provide fish passage to portions of the Sacramento, American, and Stanislaus rivers upstream of their dams would not be undertaken under Alternative 2 or the Second Basis of Comparison. **Stanislaus River/Lower San Joaquin River** The effects are identical as described under the No Action Alternative as compared to the Second Basis of Comparison. **Pacific Ocean** Killer Whale The effects are identical as described under the No Action Alternative as compared to the Second Basis of Comparison.	Not considered for this comparison.
Alternative 3	**Trinity River Region** Coho Salmon and Chinook Salmon Given the similarity of the results and the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), it is concluded that Alternative 3 and the Second Basis of	Not considered for this comparison.

Alternative	Potential Change	Consideration for Mitigation Measures
	Comparison are likely to have similar effects on Coho Salmon and Chinook Salmon in the Trinity River. Steelhead Differences in water temperature conditions for steelhead in the Trinity River would be minor as described above for salmon. These results suggest that conditions for steelhead in the Trinity River generally would be similar. Green Sturgeon The results of the water temperature analysis suggests similar effects on Green Sturgeon in the Trinity River and lower Klamath River and estuary. Reservoir Fishes Overall, reservoir storage and nest survival suggest similar effects on black bass. Pacific Lamprey and Eulachon Overall, water temperature conditions for Pacific Lamprey and Eulachon in the Trinity River and Klamath River downstream of the confluence generally would be similar. This conclusion likely also applies to other species of lamprey that inhabit the Trinity and lower Klamath rivers (e.g., River Lamprey). **Sacramento River System** Winter-run Chinook Salmon The numerical model results suggest that effects on winter-run Chinook Salmon would be similar, with a small likelihood that winter-run Chinook Salmon escapement would be higher. The ocean harvest restrictions under Alternative 3 could provide a benefit, although the effects of the predator management program are uncertain. Overall, given the small differences, distinguishing a clear difference between alternatives is difficult. The non-operational components could benefit winter-run Chinook Salmon relative to the Second Basis of Comparison over the short term if successful. Thus, the potential for adverse effects on winter-run Chinook Salmon would be slightly less under Alternative 3 than under the Second Basis of Comparison. Spring-run Chinook Salmon The numerical model results suggest that overall, effects on spring-run Chinook Salmon could be slightly more adverse with a small likelihood that spring-run Chinook Salmon production would be lower. Although the operational components could have greater adverse effects on spring-run Chinook Salmon, the non-operational components could benefit spring-run Chinook Salmon over the short term if successful. The ocean harvest restrictions could increase spring-run Chinook Salmon numbers by reducing ocean harvest and the trap and haul program and predator control measures could reduce predation on juvenile spring-run Chinook Salmon and thereby increase survival. The effects of the trap and haul and predator management programs are uncertain. Thus, the potential for adverse effects on spring-run Chinook Salmon would be slightly less under Alternative 3 than under the Second Basis of Comparison. Fall-run Chinook Salmon Overall, the results of the numerical models suggest the potential for less adverse effects on fall-run Chinook Salmon. However, discerning a meaningful difference	

Alternative	Potential Change	Consideration for Mitigation Measures
	based on the quantitative results is not possible because of the similarity in results (generally differences less than 5 percent) and the inherent uncertainty of the models. In addition, adverse effects could be offset by the potentially beneficial effects resulting from predator control and ocean harvest restrictions. Thus, the potential for adverse effects on fall-run Chinook Salmon would be slightly less under Alternative 3 than under the Second Basis of Comparison. Late Fall-run Chinook Salmon Overall, the results of the numerical models suggest the potential for less adverse effects on late fall-run Chinook Salmon. However, discerning meaningful differences based on the quantitative results is not possible because of the similarity in results (generally differences less than 5 percent) and the inherent uncertainty of the models. In addition, any adverse effects could be offset by the potentially beneficial effects resulting from predator control and ocean harvest restrictions. Thus, the effects on late fall-run Chinook Salmon would be similar under Alternative 3 and the Second Basis of Comparison. Steelhead Overall, the results of the numerical models suggest a slightly greater potential for adverse effects on steelhead. However, discerning a meaningful difference between based on the quantitative results is not possible because of the similarity in results (generally differences less than 5 percent) and the inherent uncertainty of the models. In addition, any adverse effects could be offset by the potentially beneficial effects resulting from predator control. Thus, the effects on steelhead would be similar under Alternative 3 and the Second Basis of Comparison. Green and White Sturgeon The slightly reduced frequency of exceedance of temperature thresholds could reduce the potential for adverse effects on sturgeon in the Sacramento and Feather rivers. The analysis based on Delta outflows suggests that there would be similar mean (March to July) outflows which would have similar effects on year class strength of juvenile sturgeon. Therefore, based primarily on the analysis of water temperatures, Alternative 3 could be less likely to result in adverse effects on White Sturgeon than the Second Basis of Comparison. Delta Smelt Overall, effects would be similar with regard to estimated entrainment and predicted location of Fall X2. However, given the current condition of the Delta Smelt population, even small differences between alternatives may be important. Longfin Smelt Overall, based on the decrease in frequency and magnitude of negative OMR flows and the higher Longfin Smelt abundance index values in drier years, the potential for adverse effects likely to be lower. Given the current condition of the Longfin Smelt population, even these small differences between alternatives may be important. Sacramento Splittail Flows entering the Yolo Bypass generally would be similar. Given the relatively minor changes in flows into	

Alternative	Potential Change	Consideration for Mitigation Measures
	the Yolo Bypass, and the inherent uncertainty associated with the resolution of the CalSim II model (average monthly outputs), there would be no definitive difference in effects on Sacramento Splittail between Alternative 3 and the Second Basis of Comparison. Reservoir Fishes The analysis of black bass nest survival based on changes in water surface elevation during the spawning period indicated that the likelihood of high (greater than 40 percent) nest survival in most of the reservoirs would be similar. Thus, it is likely that effects on black bass would be similar. Other Species Changes in average monthly water temperature would be small. In general, lampreys, Striped Bass, American Shad, and Hardhead can tolerate higher temperatures than salmonids. Given the similarity of the results and the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), likely to have similar effects on Striped Bass, American Shad, and Hardhead in the Sacramento, Feather, and American rivers. However, the increased bag limits and ability of anglers to retain Striped Bass that are 12 inches in length versus 18 inches could reduce the ability to meet the doubling goals for Striped Bass populations under the requirements of Section 3406(b)(1) of CVPIA. **Stanislaus River/Lower San Joaquin River** Fall-run Chinook Salmon Overall, likely would have similar effects on the fall-run Chinook Salmon population in the San Joaquin River watershed. Beneficial effects to juvenile fall-run Chinook Salmon as a result of trap and haul passage through the Delta and ocean harvest restrictions. It remains uncertain, however, if predator management actions under fall-run Chinook Salmon would benefit the fall-run Chinook Salmon population. Steelhead Given the frequency of exceedance under both Alternative 3 and the Second Basis of Comparison, water temperature conditions for steelhead in the Stanislaus River would be generally similar. Discerning a meaningful difference based on the quantitative results is not possible because of the similarity in results (generally differences less than 5 percent) and the inherent uncertainty of the models. Thus, the effects on steelhead would be similar under Alternative 3 and the Second Basis of Comparison. White Sturgeon While flows in the San Joaquin River upstream of the Stanislaus River are expected be similar, flow contributions from the Stanislaus River could influence water temperatures in the San Joaquin River where White Sturgeon eggs or larvae may occur during the spring and early summer. The magnitude of influence on water temperature would depend on the proportional flow contribution of the Stanislaus River and the temperatures in both the Stanislaus and San Joaquin rivers. The potential for an effect on White Sturgeon eggs and larvae would be influenced by the proportion of the population occurring in the San Joaquin River. In	

Alternative	Potential Change	Consideration for Mitigation Measures
	consideration of this uncertainty, it is not possible to distinguish potential effects on White Sturgeon. Reservoir Fishes The analysis of black bass nest survival based on changes in water surface elevation during the spawning period indicated that the likelihood of high (>40 percent) nest survival in New Melones would be similar to or higher. This suggests that conditions in New Melones could be more likely to support self-sustaining populations of black bass. Other Species In general, Striped Bass and Hardhead also can tolerate higher temperatures than salmonids. Given the similarity of the results and the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), it is likely that the potential effects to affect Striped Bass and Hardhead in the Stanislaus and San Joaquin rivers would be similar. However, the increased bag limits and ability of anglers to retain Striped Bass that are 12 inches in length versus 18 inches could reduce the ability to meet the doubling goals for Striped Bass populations under the requirements of Section 3406(b)(1) of CVPIA. **Pacific Ocean** Killer Whale It is unlikely that the Chinook Salmon prey base of killer whales, supported heavily by hatchery production of fall-run Chinook Salmon, would be appreciably affected.	
Alternative 4	**Trinity River Region** Coho Salmon, spring-run and fall-run Chinook Salmon, steelhead, Green Sturgeon, Reservoir Fishes, Pacific Lamprey, River Lamprey, and Eulachon The effects would be identical. **Sacramento River System** The CVP and SWP operations under Alternative 4 are identical to the CVP and SWP operations under the Second Basis of Comparison. Therefore, changes in aquatic habitat conditions at CVP and SWP reservoirs, in the rivers downstream of the reservoirs, and in the Delta would be the same as under the Second Basis of Comparison. Winter-run, spring-run, fall-run, and late fall-run Chinook Salmon, and steelhead The effects in the Sacramento River system would be similar, although Alternative 4 could produce beneficial effects to Chinook Salmon as a result of trap and haul passage through the Delta and ocean harvest restrictions. However, the magnitude of these potential benefits remain uncertain. Green Sturgeon, White Sturgeon, Delta Smelt, Longfin Smelt, Sacramento Splittail, Reservoir Fishes, Pacific Lamprey, River Lamprey, American Shad, and Hardhead The effects in the Sacramento River system would be identical. Striped Bass The effects in the Sacramento River system would be similar, although predator control would result in adverse effects on Striped Bass.	Not considered for this comparison.

Alternative	Potential Change	Consideration for Mitigation Measures
	Stanislaus River/Lower San Joaquin River Fall-run Chinook Salmon and Steelhead The effects in the Stanislaus River/Lower San Joaquin River system would be similar. Beneficial effects to Chinook Salmon as a result of trap and haul passage through the Delta and ocean harvest restrictions. It remains uncertain, however, if predator management actions would benefit the Chinook Salmon population. White Sturgeon, Reservoir Fishes, and Other Species The effects in the Stanislaus River/Lower San Joaquin River system would be identical. Striped Bass The effects in the Stanislaus River/Lower San Joaquin River system would be similar. Predation controls related to Striped Bass would result in adverse effects. **Pacific Ocean** Killer Whale It is unlikely that the Chinook Salmon prey base of killer whales, supported heavily by hatchery production of fall-run Chinook Salmon, would be appreciably affected. Beneficial effects due to benefits to fall-run Chinook Salmon as a result of trap and haul passage through the Delta and ocean harvest restrictions. It remains uncertain, however, if predator management actions would benefit the fall-run Chinook Salmon population.	
Alternative 5	**Trinity River Region** Coho Salmon, Spring-run Chinook Salmon, Fall-run Chinook Salmon, and Steelhead Monthly water temperature generally would be similar (less than 0.5°F differences), with the exception of drier years when temperatures could be as much as 2.2°F cooler in November and 1.5°F warmer in December. Average monthly water temperatures could be slightly (up to 0.6°F) higher during July and August and lower (up to 0.7°F) in September. Lower September temperatures may result in slightly better conditions for spring-run Chinook Salmon spawning. Similarly, temperature conditions could be slightly better for fall-run Chinook Salmon spawning because of the reduced temperatures in November during critical dry years. Water temperature thresholds for Coho Salmon, fall-run Chinook Salmon, and steelhead would be exceeded slightly more frequently (less than 1 percent), whereas thresholds for spring-run Chinook Salmon would be exceeded less frequently (up to 4 percent) in August in September. Discerning a meaningful difference based on the quantitative results is not possible because of the similarity in results (generally differences less than 5 percent) and the inherent uncertainty of the models. In addition, implementation of a Hatchery Management Plan could reduce the impacts of hatchery Chinook Salmon on natural Chinook Salmon in the Trinity River and increase the genetic diversity and diversity of run-timing for these stocks, but the potential magnitude of these benefits is uncertain. Alternative 5 is likely to have similar effects on Chinook Salmon and steelhead in the Trinity River. Reservoir Fishes Overall, the comparison of storage and the analysis of nesting suggest that effects would be similar.	Not considered for this comparison.

Alternative	Potential Change	Consideration for Mitigation Measures
	Other Species The minor differences in average monthly water temperatures described above for salmonids apply to Pacific Lamprey, Eulachon, and other aquatic species in the Trinity River. These minor differences suggest that conditions for aquatic species in the Trinity River and Klamath River downstream of the confluence generally would be similar under Alternative 5 and the Second Basis of Comparison. **Sacramento River System** Winter-run Chinook Salmon Overall, the quantitative results from the numerical models suggest that operations would be less likely to result in adverse effects on winter-run Chinook Salmon. In consideration of the potentially beneficial effects resulting from actions that are not included in the numerical models, the potential for adverse effects on winter-run Chinook Salmon under Alternative 5 would clearly be less than those under the Second Basis of Comparison, principally because the Second Basis of Comparison does not include a strategy to address water temperatures critical to winter-run Chinook Salmon sustainability over the long term with climate change by 2030. Spring-run Chinook Salmon The numerical model results suggest that, overall, Alternative 5 likely would have similar or slightly greater adverse effects on the spring-run Chinook Salmon population in the Sacramento River watershed as compared to the Second Basis of Comparison. The potential for adverse effects on spring-run Chinook Salmon suggested by the results of the numerical models would likely be offset by the potential benefits of the actions that are not included in the numerical models, principally because the Second Basis of Comparison does not include a strategy to address water temperatures critical to spring-run Chinook Salmon sustainability over the long term with climate change by 2030. On balance and over the long term, the adverse effects on spring-run Chinook Salmon under Alternative 5 would be less than those under the Second Basis of Comparison. Fall-run Chinook Salmon Overall, the results of the numerical models suggest the potential for greater adverse effects on fall-run Chinook Salmon. However, discerning a meaningful difference between these two scenarios based on the quantitative results is difficult because of the similarity in results (generally differences less than 5 percent), the inherent uncertainty of the models, and the potential for offsetting benefits. Thus, the effects on fall-run Chinook Salmon would be similar. Late Fall-run Chinook Salmon The numerical model results suggest that overall, Alternative 5 is likely to have less adverse effect on late fall-run Chinook Salmon in the Sacramento River. Benefits may be enhanced by actions intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities to improve the overall salvage survival of salmonids, including late fall-run Chinook Salmon. Thus, the potential for adverse effects on late fall-run Chinook Salmon would be less under Alternative 5 relative to the Second Basis of Comparison.	

Alternative	Potential Change	Consideration for Mitigation Measures
	<u>Steelhead</u> The numerical model results suggest that overall, effects on steelhead could be slightly more adverse, particularly in the Feather and American rivers. However, implementation of a fish passage program intended to address the limited availability of suitable habitat for steelhead in the Sacramento River reaches downstream of Keswick Dam and in the American River could provide a benefit to Central Valley steelhead in the Sacramento and American rivers. This is particularly important in light of anticipated increases in water temperature associated with climate change in 2030. In addition to fish passage, preparation and implementation of an HGMP for steelhead at the Nimbus Fish Hatchery and actions intended to increase the efficiency of the Tracy and Skinner Fish Collection Facilities could benefit steelhead. Thus, on balance and over the long term, the adverse effects on steelhead under Alternative 5 would be less than those under the Second Basis of Comparison. <u>Green Sturgeon</u> Overall, the increased frequency of exceedance of temperature thresholds could increase the potential for adverse effects on Green Sturgeon in the Sacramento and Feather rivers. However, analysis based on Delta outflows suggests that Alternative 5 provides higher mean (March to July) outflows which could result in stronger year classes of juvenile sturgeon relative to the Second Basis of Comparison. However, early life stage survival in the natal rivers is crucial in development of a strong year class; therefore, based primarily on the analysis of water temperatures, Alternative 5 could be more likely to result in adverse effects on Green Sturgeon than the Second Basis of Comparison. <u>White Sturgeon</u> The increased frequency of exceedance of temperature thresholds under Alternative 5 could increase the potential for adverse effects on White Sturgeon relative to the Second Basis of Comparison. However, the analysis based on Delta outflows suggests that the No Action Alternative provides higher mean (March to July) outflows which could result in stronger year classes of juvenile sturgeon relative to the Second Basis of Comparison. Early life stage survival in the natal rivers is crucial in development of a strong year class; therefore, based primarily on the analysis of water temperatures, Alternative 5 could be more likely to result in adverse effects on White Sturgeon than the Second Basis of Comparison. <u>Delta Smelt</u> Overall, likely would result in better conditions for Delta Smelt, primarily due to lower percentage entrainment for larval and juvenile life stages, and more favorable location of Fall X2 in wetter years, and on average. Given the current condition of the Delta Smelt population, even small differences between alternatives may be important. <u>Longfin Smelt</u> Overall, based on the decrease in frequency and magnitude of negative OMR flows and the higher Longfin Smelt abundance index values, especially in dry and critical dry years, potential adverse effects on the Longfin Smelt population likely would be less.	

Alternative	Potential Change	Consideration for Mitigation Measures
	Sacramento Splittail Overall, the slight adverse effects related to spawning habitat for Sacramento Splittail because of the decreased area of potential habitat (inundation) and the potential for a slight decrease in the frequency of inundation. Given the relatively minor changes in flows into the Yolo Bypass, and the inherent uncertainty associated with the resolution of the CalSim II model, no definitive difference in effects on Sacramento Splittail could be discerned. Reservoir Fishes The analysis of black bass nest survival based on changes in water surface elevation during the spawning period indicated that the likelihood of high (greater than 40 percent) nest survival in most of the reservoirs would be similar. Overall, the results of the nest survival analysis suggest that effects on reservoir fishes would be similar. Pacific Lamprey Given the similarity of the results and the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs),it is likely that conditions for and effects on Pacific Lamprey in the Sacramento, Feather, and American rivers would be similar. This conclusion likely applies to other species of lamprey that inhabit these rivers (e.g., River Lamprey). Striped Bass, American Shad, and Hardhead In general, Striped Bass, American Shad, and Hardhead can tolerate higher temperatures than salmonids. Given the similarity of the results and the inherent uncertainty associated with the resolution of the temperature model, it is likely that thermal conditions for and effects on Striped Bass, American Shad, and Hardhead in the Sacramento, Feather, and American rivers would be similar. Overall, Alternative 5 likely would have similar effects on Hardhead and a slightly lower potential for adverse effects on Striped Bass, American Shad, and Hardhead as compared to the Second Basis of Comparison, primarily due to the potential for increased survival for these two species during larval and juvenile life stages, and more favorable location of Spring X2 on average. **Stanislaus River/Lower San Joaquin River** Fall-run Chinook Salmon The analysis of temperatures indicates lower temperatures and a lesser likelihood of exceedance of suitable temperatures for spawning and rearing of fall-run Chinook Salmon in the Stanislaus River below Goodwin Dam and in the San Joaquin River at Vernalis. As described above, the instream flow patterns are anticipated to benefit fall-run Chinook Salmon in the Stanislaus River and downstream in the lower San Joaquin River below Vernalis. Implementation of a fish passage project under Alternative 5, intended to address the limited availability of suitable habitat for steelhead in the Stanislaus River reaches downstream of Goodwin Dam, likely would not provide benefit to fall-run Chinook Salmon unless passage was provided and additional habitat could be accessed. Potential benefits to fall-run Chinook Salmon associated with fish passage is nevertheless uncertain. However, actions implemented under Alternative 5 intended to increase the efficiency of the Tracy and	

Alternative	Potential Change	Consideration for Mitigation Measures
	Skinner Fish Collection Facilities could improve the overall salvage survival of fall-run Chinook Salmon.Overall, given the small differences in the modeling results and the potential benefits anticipated by actions not captured in the models, effects on fall-run Chinook Salmon would be similar. Steelhead Given the frequency of exceedance and the generally stressful temperature conditions in the river, the substantial lower temperatures in October and April suggest that there would be less potential to result in adverse effects on steelhead. Implementation of a fish passage program under Alternative 5 intended to address the limited availability of suitable habitat for steelhead in the Stanislaus River reaches downstream of Goodwin Dam could provide a benefit to steelhead, In addition, the potential effects of Alternative 5 could be offset by actions intended to reduce predation risk on steelhead in the Stanislaus River and increase the efficiency of the Tracy and Skinner Fish Collection Facilities. The actions to augment spawning gravel in the Stanislaus River under Alternative 5 also could benefit steelhead. The numerical model results for effects on steelhead under Alternative 5 and Second Basis of Comparison do not definitively show distinct differences. However, in consideration of the potentially beneficial effects resulting from the actions that would be implemented under Alternative 5 that are not included in the numerical models, Alternative 5 has a much greater potential to address the long-term sustainability of steelhead than does the Second Basis of Comparison. Alternative 5 includes provisions for fish passage upstream of New Melones Dam to address long-term temperature increases associated with climate change. Even though the success of fish passage is uncertain, the potential for adverse effects on steelhead under Alternative 5 would clearly be less than that under the Second Basis of Comparison, principally because the Second Basis of Comparison does not include a strategy to address water temperatures critical to steelhead sustainability over the long term with climate change by 2030. White Sturgeon Evidence of White Sturgeon spawning has been recorded in the San Joaquin River upstream of the confluence with the Stanislaus River. While flows in the San Joaquin River upstream of the Stanislaus River are expected be similar under all alternatives, flow contributions from the Stanislaus River could influence water temperatures in the San Joaquin River where White Sturgeon eggs or larvae may occur during the spring and early summer. The magnitude of influence on water temperature would depend on the proportional flow contribution of the Stanislaus River and the temperatures in both the Stanislaus and San Joaquin rivers. The potential for an effect on White Sturgeon eggs and larvae would be influenced by the proportion of the population occurring in the San Joaquin River. In consideration of this uncertainty, it is not possible to distinguish potential effects on White Sturgeon between alternatives. Reservoir Fishes Overall, the analysis suggests that conditions under Alternative 5 have the potential to influence black bass	

Alternative	Potential Change	Consideration for Mitigation Measures
	nesting success, especially in April and May in comparison to the Second Basis of Comparison. However, nesting success under Alternative 5 would still exceed 40 percent most of the time under both alternatives. Therefore, there would be no definitive difference in effects on reservoir fish between Alternative 5 and the Second Basis of Comparison. <u>Other Species</u> In general, Striped Bass and Hardhead can tolerate higher temperatures than salmonids. Given the similar flows and temperatures during their spawning and incubation period, it is likely that the potential to affect Striped Bass and Hardhead in the Stanislaus and San Joaquin rivers would be similar. **Pacific Ocean** <u>Killer Whale</u> Given conclusions from NMFS (2009c), and the fact that at least 75 percent of fall-run Chinook Salmon available for Southern Residents are produced by Central Valley hatcheries, it is likely that Central Valley fall-run Chinook Salmon as a prey base for killer whales would not be appreciably affected.	

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.”

9.4.3.8 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.

Changes in CVP and SWP operations under Alternatives 1 through 5 as compared to the No Action Alternative would result in adverse impacts. Potential mitigation measures that could be considered to reduce the adverse water temperature impacts include implementation of fish passage programs. Mitigation measures for other substantial adverse impacts have not been identified at this time.

9.4.3.8.1 Fish Passage Programs

Implementation of Alternatives 1, 2, 3, and 4 would result in adverse impacts due to high water temperatures in the streams downstream of the dams. A potential mitigation measure to reduce these effects would be:

- Implement fish passage programs at Shasta and Keswick, Oroville and Thermalito, Folsom and Nimbus, and New Melones dams to reduce temperature impacts on Chinook Salmon and steelhead under Alternatives 1, 2, 3, and 4.

These programs would be similar to programs implemented under the 2009 NMFS BO, as included in the No Action Alternative and Alternative 5. This mitigation measure would be in response to the climate change effects anticipated in 2030 in addition to the changes under Alternatives 1, 2, 3, and 4.

9.4.3.9 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 under Alternatives 1 through 5 for Fish and Aquatic Resources are summarized in Table 9.6.

Table 9.6 Summary of Cumulative Effects on Fish and Aquatic 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 Alterantive and in All Alternatives in Year 2030	Consistent with Affected Environment conditions plus: 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) 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), including climate change and sea level rise: • 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 • General plans for 2030. • Trinity River Restoration Program. • Central Valley Project Improvement Act programs • Iron Mountain Mine Superfund Site • Nimbus Fish Hatchery Fish Passage Project • Folsom Dam Water Control Manual Update	<u>These effects would be the same under all alternatives.</u> 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 carryover storage in reservoirs, stream flows and Delta outflow, and the availability of CVP and SWP water supplies as compared to past conditions. These future actions could modify surface water conditions (e.g., flow) and affect habitat for fish and aquatic resources. However, many of these actions are intended to improve habitat conditions for aquatic resources or water quality, and thus the alternatives would not contribute to an adverse cumulative effect on aquatic resources. In addition, these actions were or would be subject to compliance with ESA, CESA, and other environmental laws and requirements, which serve to reduce the potential for impacts on aquatic resources.

Scenarios	Actions	Cumulative Effects of Actions
	• FERC Relicensing for the Middle Fork of the American River Project • Lower Mokelumne River Spawning Habitat Improvement Project • Dutch Slough Tidal Marsh Restoration • Suisun Marsh Habitat Management, Preservation, and Restoration Plan Implementation • Tidal Wetland Restoration: Yolo Ranch, Northern Liberty Island Fish Restoration Project, Prospect Island Restoration Project, and Calhoun Cut/Lindsey Slough Tidal Habitat Restoration Project • San Joaquin River Restoration Program • Stockton Deep Water Ship Channel Dissolved Oxygen Project • Grasslands Bypass Project • Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS)	
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): • Bay-Delta Water Quality Control Plan Update • FERC Relicensing Projects • Bay Delta Conservation Plan (including the California WaterFix alternative) • Shasta Lake Water Resources Investigation, North-of-the-Delta Offstream Storage, Los Vaqueros Reservoir Expansion Phase 2, and Upper San Joaquin River Basin Storage Investigations • El Dorado Water and Power Authority Supplemental Water Rights Project • Sacramento River Water Reliability Project • Semitropic Water Storage District Delta Wetlands	These effects would be the same under all alternatives. Most of the future reasonably foreseeable actions are anticipated to reduce water supply impacts due to climate change, sea level rise, and increased water allocated to improve habitat conditions. It is unclear how these future reasonably foreseeable actions would influence aquatic resources because project details are not available. However, as described above, these actions would be subject to environmental regulations that avoid or limit the potential for cumulative effects on aquatic resources. Some of these actions (e.g., FERC relicensing projects) could cumulatively contribute to reducing adverse effects of climate change on aquatic resources if fish passage and improved water temperature control result from the FERC process.

Scenarios	Actions	Cumulative Effects of Actions
	• North Bay Aqueduct Alternative Intake • Irrigated Lands Regulatory Program • San Luis Reservoir Low Point Improvement Project • *Westlands Water District v. United States Settlement* • 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)	
No Action Alternative with Associated Cumulative Effects in Year 2030	Full implementation of the 2008 USFWS BO and 2009 NMFS BO	Implementation of No Action Alternative would result in changes in stream flows, increased Delta outflow, and reduced CVP and SWP water supplies as compared to conditions prior to the BOs. These RPA actions are intended and anticipated to put fish and aquatic resources on a more favorable trajectory than would occur without these actions.
Alternative 1 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 Alternatives 1 and 4 with reasonably foreseeable actions would result in changes in stream flows, reduced Delta outflows, and increased CVP and SWP water exports as compared to the No Action Alternative with reasonably foreseeable actions. Favorable conditions for listed salmonids could be less available as compared to the No Action Alternative because access to habitat upstream of Shasta, Folsom, and New Melones dams would not be available. In addition, implementation of these alternatives could contribute cumulatively to impacts on listed Delta species by comparison to the No Action Alternative with reasonably foreseeable 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. No implementation of structural improvements or other actions that require further study to develop a more detailed action description.	The effects of Alternative 2 on water temperature relative to the No Action Alternative could contribute incrementally to the cumulative effects on listed salmonids because the alternative provides no mechanism for addressing long-term temperature increases.

Scenarios	Actions	Cumulative Effects of 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) Slight increase in positive Old and Middle River flows in the winter and spring months Increased bag limits for Striped Bass and Pikeminnow Increased ocean salmon fishing harvest limitations	Implementation of Alternatives 1 and 4 with reasonably foreseeable actions would result in changes in stream flows, reduced Delta outflows, and increased CVP and SWP water exports as compared to the No Action Alternative with reasonably foreseeable actions. Favorable conditions for listed salmonids could be less available as compared to the No Action Alternative because access to habitat upstream of Shasta, Folsom, and New Melones dams would not be available. In addition, implementation of these alternatives could contribute cumulatively to impacts on listed Delta species by comparison to the No Action Alternative with reasonably foreseeable 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) Increased bag limits for Striped Bass and Pikeminnow Increased ocean salmon fishing harvest limitations No implementation of the USACE vegetation standards for levees	Implementation of Alternatives 1 and 4 with reasonably foreseeable actions would result in changes in stream flows, reduced Delta outflows, and increased CVP and SWP water exports as compared to the No Action Alternative with reasonably foreseeable actions. Favorable conditions for listed salmonids could be less available as compared to the No Action Alternative because access to habitat upstream of Shasta, Folsom, and New Melones dams would not be available. In addition, implementation of these alternatives could contribute cumulatively to impacts on listed Delta species by comparison to the No Action Alternative with reasonably foreseeable actions.
Alternative 5 with Associated Cumulative Effects in Year 2030	Full implementation of the 2008 USFWS BO and 2009 NMFS BO Positive Old and Middle River flows and increased Delta outflow in spring months	Implementation of Alternative 5 with reasonably foreseeable actions would result in changes in stream flows, increased Delta outflows, and reduced CVP and SWP water exports as compared to the No Action Alternative with these added actions.

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Chapter 10

Terrestrial Biological Resources

10.1 Introduction

This chapter describes terrestrial biological resources 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 terrestrial biological resources through potential changes in operation of the Central Valley Project (CVP) and State Water Project (SWP) and ecosystem restoration.

10.2 Regulatory Environment and Compliance Requirements

Potential actions that could be implemented under the alternatives evaluated in this EIS could affect terrestrial biological resources in areas: along the shorelines and in the waters of reservoirs that store CVP and SWP water supplies, along rivers and waterways (including bypasses) impacted by changes in the operations of CVP or SWP reservoirs, within agricultural areas served by CVP and SWP water supplies, and modified to provide wetland habitat. 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.

10.3 Affected Environment

This section describes terrestrial biological resources that could potentially be affected by implementing the alternatives considered in this EIS. Changes in terrestrial biological 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.

Terrestrial biological resources occur throughout the study area. However, the analysis in this EIS is focused on terrestrial biological resources that could be directly or indirectly affected by the implementation of the alternatives analyzed in this EIS. The areas that could be affected are related to specific areas: 1) along the shorelines of reservoirs that store CVP and SWP water supplies, 2) along rivers downstream of CVP or SWP reservoirs, 3) areas with wetland habitat restoration in the Yolo Bypass and Suisun Marsh, 4) wildlife refuges that receive CVP water supplies, 5) riparian corridors within the Delta, and 6) within agricultural acreage that is irrigated with CVP and SWP water supplies.

Therefore, the following description of the affected environment is limited to these areas.

10.3.1 Overview of Species with Special Status

Species with special status are defined as species that are legally protected or otherwise considered sensitive by Federal, state, or local resource agencies, including:

- Species listed by the Federal government as threatened or endangered,
- Species listed by the State of California as threatened, endangered, or rare (rare status is for plants only),
- Species that are formally proposed for Federal listing or are candidates for Federal listing as threatened or endangered,
- Species that are candidates for State listing as threatened or endangered,
- Species that meet the definitions of rare, threatened, or endangered under California Environmental Quality Act,
- Species identified by the U.S. Fish and Wildlife Service (USFWS) as Birds of Conservation Concern,
- Species considered sensitive by the U.S. Bureau of Land Management (BLM) or U.S. Forest Service (USFS),
- Species identified by California Department of Fish and Wildlife (CDFW) as species of special concern, species designated by California statute as fully protected (e.g., California Fish and Game Code, sections 3511 [birds], 4700 [mammals], and 5050 [reptiles and amphibians] and 5515 [fish]) or bird species on the CDFW Watch List, and
- Species, subspecies, and varieties of plants considered by CDFW and California Native Plant Society (CNPS) to be rare, threatened, or endangered in California. The CNPS Inventory of Rare and Endangered Plants of California assigns California Rare Plant Ranks (CRPR) categories for plant species of concern. Only plant species in CRPR categories 1 and 2 are considered special status plant species in this document:
  - CRPR 1A—Plants presumed to be extinct in California.
  - CRPR 1B—Plants that are rare, threatened, or endangered in California and elsewhere.
  - CRPR 2—Plants that are rare, threatened, or endangered in California but more common elsewhere.

A listing of wildlife and plant species with special status that occur or may occur in portions of the study area and are affected by the long-term coordinated operation of the CVP and SWP is provided in Appendix 10A. Relevant documents used to assemble these resource lists include the list of Federal endangered and threatened species that occur in or may be affected by projects in the counties within the study area generated on-line from the USFWS Sacramento Fish and Wildlife Office.

To supplement the U.S. Fish and Wildlife lists, the California Natural Diversity Database (CNDDB) was queried (DFG 2012) for regions where recent documentation was lacking. This included the Stanislaus River corridor between New Melones Dam and the San Joaquin River confluence, and the Trinity River Region, including Trinity Lake, Lewiston Reservoir, Whiskeytown Lake, and Clear Creek between Carr Powerhouse and the Sacramento River confluence.

10.3.1.1 Critical Habitat

Critical habitat refers to areas designated by the USFWS for the conservation of species listed as threatened or endangered under the Endangered Species Act of 1973, as amended through the 108th Congress (ESA). When a species is proposed for listing under the ESA, the USFWS considers whether there are certain areas essential to the conservation of the species. Critical habitat is defined in Section 3, Provision 5 of the ESA as follows.

> *(5)(A) The term "critical habitat" for a threatened or endangered species means -*
>
> > *(i) the specific areas within the geographical area occupied by a species at the time it is listed in accordance with the Act, on which are found those physical or biological features (I) essential to the conservation of the species, and (II) which may require special management considerations or protection; and*
> >
> > *(ii) specific areas outside the geographical area occupied by a species at the time it is listed in accordance with the provisions of section 4 of this Act, upon a determination by the Secretary that such areas are essential for the conservation of the species.*

Any Federal action (permit, license, or funding) in critical habitat requires that Federal agency to consult with the USFWS where the action has potential to adversely modify the habitat for terrestrial species.

The federally listed wildlife and plant species considered in this EIS that have designated critical habitat areas that could be affected by modification of CVP and SWP operations are presented in Table 10.1 below. There are occurrences of critical habitat of other species not included in Table 10.1 or other locations of critical habitat of the species listed in Table 10.1 which are not included below because those occurrences are not located within the CVP or SWP service areas or in areas that could be affected by modification of CVP and SWP operations, such as lands located at high elevations within national forests where CVP and SWP water is not delivered.

Table 10.1 Terrestrial Species with Designated Critical Habitat in Portions of the Study Area that Could Be Affected by Changes in CVP and SWP Operations

Species	Regions*	Counties
Least Bell's Vireo	Central Coast and Southern California	Riverside, San Bernardino, San Diego, Santa Barbara, Ventura
Buena Vista Lake Shrew	Central Valley	Kern
Fresno Kangaroo Rat	Central Valley	Fresno
California Tiger Salamander	Central Valley	Alameda, Kern, Kings, Madera, Merced, San Benito, San Joaquin, Santa Barbara, Solano, Stanislaus, Tulare, Yolo
California Red-legged Frog	Central Valley, San Francisco Bay Area, Central Coast, Southern California	Alameda, Butte, Contra Costa, El Dorado, Kern, Kings, Los Angeles, Merced, Nevada, Placer, San Benito, San Joaquin, Santa Barbara, Santa Clara, Solano, Stanislaus, Ventura, Yuba
Alameda Whipsnake	Central Valley and San Francisco Bay Area	Alameda, San Joaquin, Santa Clara
Valley Elderberry Longhorn Beetle	Central Valley	Sacramento
Conservancy Fairy Shrimp	Central Valley	Butte, Merced, Solano, Stanislaus, Tehama, Ventura
Longhorn Fairy Shrimp	Central Valley	Alameda, Contra Costa, Merced
Vernal Pool Fairy Shrimp	Central Valley and San Francisco Bay Area	Alameda, Butte, Contra Costa, Fresno, Glenn, Madera, Merced, Placer, Sacramento, San Benito, San Joaquin, Santa Barbara, Shasta, Solano, Stanislaus, Tehama, Tulare, Ventura, Yuba
Vernal Pool Tadpole Shrimp	Central Valley	Alameda, Colusa, Kings, Madera, Merced, Sacramento, Shasta, Solano, Stanislaus, Tehama, Tulare, Yolo, Yuba
Butte County Meadowfoam	Central Valley	Butte, Tehama
Colusa Grass	Central Valley	Merced, Stanislaus, Yolo
Hairy Orcutt Grass	Central Valley	Butte, Fresno, Madera, Merced, Stanislaus, Tehama
San Joaquin Hairy Orcutt Grass	Central Valley	Fresno, Madera, Merced, Tulare
Slender Orcutt Grass	Central Valley	Plumas, Sacramento, Shasta, Tehama

Species	Regions*	Counties
Sacramento Orcutt Grass	Central Valley	Sacramento
Solano Grass	Central Valley	Yolo
Contra Costa Goldfields	Central Valley	Solano
Contra Costa Wallflower	Central Valley and San Francisco Bay Area	Contra Costa, Sacramento
Fleshy Owl's-Clover	Central Valley	Madera, Merced, Sacramento, San Joaquin, Stanislaus
Greene's Tuctoria	Central Valley	Madera, Merced, Shasta, Stanislaus, Tehama
Hoover's Spurge	Central Valley	Butte, Merced, Tehama, Tulare
Keck's Checker-Mallow	Central Valley	Fresno
Soft Bird's-Beak	Central Valley and San Francisco Bay Area	Contra Costa, Solano
Suisun Thistle	Central Valley	Solano

Source: USFWS 2014a - 2014aj

Note:
* Only includes critical habitat within lands served by CVP or SWP water or in areas that could be affected by modification of CVP and SWP operations. Therefore, does not include lands where CVP and SWP water is not delivered or not affected by CVP and SWP operations.

10.3.2 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 lower Klamath River from the confluence with the Trinity River to the Pacific Ocean. The Trinity River Region includes Trinity Lake, Lewiston Reservoir, the Trinity River between Lewiston Reservoir and the confluence with the Klamath River, and along the lower Klamath River.

The Trinity River includes the mainstem, North Fork Trinity River, South Fork Trinity River, New River, and numerous smaller streams (NCRWQCB et al. 2009; USFWS et al. 1999). The mainstem of the Trinity River flows 170 miles to the west from the headwaters to the confluence with the Klamath River. As described in Chapter 5, Surface Water Resources and Water Supplies, the CVP Trinity Lake and Lewiston Reservoir are located upstream of the confluences of the Trinity River and the North Fork, South Fork, and New River. Flows on the North Fork, South Fork, and New River are not affected by CVP facilities. The Trinity River flows approximately 112 miles from Lewiston Reservoir to the Klamath River through Trinity and Humboldt counties and the Hoopa Indian Reservation within Trinity and Humboldt counties. The Trinity River is the largest tributary to the Klamath River (DOI and DFG 2012).

The lower Klamath River flows 43.5 miles from the confluence with the Trinity River to the Pacific Ocean (USFWS et al. 1999). Downstream of the Trinity River confluence, the Klamath River flows through Humboldt and Del Norte counties and through the Hoopa Indian Reservation, Yurok Indian Reservation, and Resighini Indian Reservation within Humboldt and Del Norte counties (DOI and DFG 2012). There are no dams located in the Klamath River watershed downstream of the confluence with the Trinity River. The Klamath River estuary extends from approximately 5 miles upstream of the Pacific Ocean. This area is generally under tidal effects and salt water can occur up to 4 miles from the coastline during high tides in summer and fall when Klamath River flows are low.

As described in subsection 10.3.2, Overview of Species with Special Status, a listing of wildlife and plant species with special status that occur or may occur in portions of the study area affected by the long-term coordinated operation of the CVP and SWP is provided in Appendix 10A.

10.3.2.1 Trinity Lake and Lewiston Reservoir

The dominant vegetation community in the Trinity River watershed upstream of Trinity Lake and Lewiston Reservoir includes mixed conifer, with ponderosa pine, sugar pine, and Douglas-fir as the dominant species. Some south-facing slopes are dominated by oak and brush. Mixed hardwood communities occur at lower elevations, and include species such as madrone, big-leaf maple, and a variety of oaks. The shrub community at lower elevations includes a number of chaparral species such as manzanita, bitterbrush, and deerbrush. South-facing slopes around Trinity Lake contain shrub fields that provide winter range for the Weaverville deer herd (USFS 2005; STNF 2014)

Along the margins of Trinity Lake and Lewiston Reservoir, vegetation is consistent with species associated with a reservoir environment and standing water, including floating species, rooted aquatic species, and emergent wetland species. Emergent wetland and riparian vegetation is constrained by fluctuating water levels and steep banks (NCRWQCB et al. 2009; USFWS et al. 1999).

The reservoirs attract resting and foraging waterfowl and other species that favor standing or slow moving water. Impounded water in the reservoirs also provides foraging habitat for eagles and other raptors that prey on fish (e.g., ospreys) and waterfowl.

Recently, ten pairs of mating bald eagles were observed at Trinity Lake and three pairs at Lewiston Lake (USFS 2012).

10.3.2.2 Trinity River from Lewiston Reservoir to Klamath River

Current terrestrial habitat along the Trinity River is different than habitat prior to construction of Trinity and Lewiston dams. The ongoing Trinity River Restoration Program is restoring portions of the habitat. The following description reflects recent habitat changes along the mainstem of the Trinity River between Lewiston Reservoir and the confluence of the Klamath River.

10.3.2.2.1 Trinity River Restoration Program

The hydrologic and geomorphic changes following construction of the Trinity and Lewiston dams changed the character of the river channel substantially and allowed riparian vegetation to encroach on areas that had previously been scoured by flood flows (USFWS et al. 1999). This resulted in the formation of a riparian berm that armored and anchored the river banks and prevented meandering of the river channel. The berm reduced the potential for encroachment and maturation of woody vegetation along the stabilized channel. In addition, the extent of wetlands probably declined following dam construction due, in part, to reduced flows and elimination of river meanders.

The ongoing Trinity River Restoration Program includes specific minimum instream flows, as described in Chapter 5, Surface Water Resources and Water Supplies; mechanical channel rehabilitation; fine and coarse sediment management; watershed restoration; infrastructure improvement; and adaptive management components (NCRWQCB et al. 2009; USFWS et al. 1999). The mechanical channel rehabilitation includes removal of fossilized riparian berms that had been anchored by extensive woody vegetation root systems and consolidated sand deposits, and thereby, had confined the river. Following removal of the berms, the areas had been re-vegetated to support native vegetation, re-establish alternate point bars, and re-establish complex fish habitat similar to conditions prior to construction of the dams. Sediment management activities include introduction of coarse sediment at locations to support spawning and other aquatic life stages; and relocation of sand outside of the floodway. In areas closer to Lewiston Dam with limited gravel supply, gravel/cobble point bars are being rebuilt to increase gravel storage and improve channel dynamics. Riparian vegetation planted on the restored floodplains and flows will be managed to encourage natural riparian growth on the floodplain and limit encroachment on the newly formed gravel bars. Improvement projects have been completed and others are under construction or in the planning phases. The restoration actions are occurring between Lewiston Dam and the North Fork.

10.3.2.2.2 Terrestrial Habitat

Between the North Fork and the South Fork, the Trinity River channel is restricted by steep canyon walls that limit riparian vegetation to a narrow band (NCRWQCB et al. 2009; USFWS et al. 1999). Between the South Fork and the confluence with the Klamath River, there are confined reaches with little riparian vegetation, alternating with vegetation similar to the pre-dam conditions in the upper reach below Lewiston dam.

Many wildlife species that inhabited river and riparian habitats prior to dam construction still occur along the Trinity River. Species that prefer early-successional stages or require greater riverine structural diversity are likely to be less abundant under current conditions (NCRWQCB et al. 2009; USFWS et al. 1999). For example, western pond turtle declined since completion of the dams in response to diminishing instream habitat. In contrast, species such as northern goshawk and black salamander that favor mature, late-successional riparian habitats increased with more upland habitat along the riparian corridor.

Current habitats along the Trinity River include annual grassland, fresh emergent wetland, montane riparian, valley-foothill riparian, and riverine habitats (NCRWQCB et al. 2009, 2013). The annual grassland species include grasses (e.g., wild oat, soft brome, ripgut brome, cheatgrass, and barley); forbs (e.g., broadleaf filaree, California poppy, true clover, and bur clover); and native perennial species (e.g., Creeping Wildrye). The annual grassland habitat supports Mourning Dove, Savannah Sparrow, White-Crowned Sparrow, American Kestrel, Red-Tailed Hawk, coyote, California Ground Squirrel, Botta’s Pocket Gopher, California Kangaroo Rat, Deer Mouse, Gopher Snake, Western Fence Lizard, Western Skink, Western Rattlesnake, and Yellow-Bellied Racer. The fresh emergent wetland species occur along the backwater areas, depressions, and along the river edges, including American Tule, Narrow-Leaved Cattail, Dense Sedge, Perennial Ryegrass, Himalayan Blackberry, and Narrow-Leaved Willow. Wildlife species along the fresh emergent wetland include Western Toad, Pacific Chorus Frog, Bullfrog, Green Heron, Mallard, and Red-Winged Blackbird. The montane riparian habitat adjacent to the river include trees, including bigleaf maple, white alder, oregon ash, black cottonwood, and Goodding’s black willow; and understory species, including mugwort, virgin’s bower, American dogwood, oregon golden-aster, dalmatian toadflax, white sweet clover, musk monkeyflower, straggly gooseberry, California grape, and California blackberry. The valley-foothill riparian habitat occur along alluvial fans, slightly dissected terraces, and floodplains; and include cottonwood, California sycamore, valley oak, white alder, boxelder, Oregon ash, wild grape, wild rose, California blackberry, blue elderberry, poison oak, buttonbush, willow, sedge, rushes, grasses, and miner’s lettuce. Riparian woodlands along the montane riparian habitat support breeding, foraging, and roosting habitat for tree swallow, bushtit, White-Breasted Nuthatch, Nuttall’s Woodpecker, Downy Woodpecker, Spotted Towhee, and Song Sparrow; cover for amphibians, including Western Toad and Pacific Chorus Frog; and habitat for deer mouse, raccoon, and Virginia Opossum. The riverine habitat supports amphibians and reptiles, including Western Toad, Pacific Chorus Frog, bullfrog, and Western Pond Turtle; birds, including mallard, Great Blue Heron, Osprey, and Belted Kingfisher; and mammals, including river otter, beaver, Big Brown Bat, and Yuma Myotis (bat).

The lands upslope of the Trinity River are characterized by mixed chaparral, montane hardwood-conifer, blue oak-foothill pine, foothill pine, and Klamath mixed conifer (NCRWQCB et al. 2009, 2013). The trees include Pacific madrone, bigleaf maple, canyon live oak, black oak, blue oak, ponderosa pine, Douglas fir, and incense cedar. Shrubs include greenleaf manzanita, buckbrush, cascara, snowberry, and poison oak. Underlying herbaceous vegetation includes ripgut brome, blue wild rye, silver bush lupine, purple sanicle, false hedge-parsley, The habitats support numerous birds, including Northern Flicker, Stellar’s Jay, Hairy Woodpecker, Acorn Woodpecker, Wrentit, Bewick’s Wren, California Quail, Mountain Quail, Blue Grouse, Sharp-Shinned Hawk, Red-Tailed Hawk, and Great Horned Owl; mammals including Black-Tailed Deer, Gray Fox, coyote, Black-Tailed Jackrabbit, Raccoon, Virginia Opossum, Spotted Skunk, Gray Squirrel, Allen's Chipmunk, Deer Mouse, and Pallid Bat; and reptiles and amphibians, including California Kingsnake, Western Rattlesnake, Sharp-Tailed Snake, Western Fence Lizard, Southern Alligator Lizard, and Ensatina.

Inundation of lands by Trinity Lake, Lewiston Reservoir, and Whiskeytown Lake inundated approximately 20,500 acres of habitat for an estimated 8,500 black-tailed deer (USFWS 1975). The CDFW established a deer herd management plan for the Critical Winter Range for the Weaverville deer herd. A portion of the winter range is located along the Trinity River (NCRWQCB et al. 2009).

10.3.2.3 Lower Klamath River Watershed from Trinity River to the Pacific Ocean

The Klamath River from the confluence with the Trinity River to the Pacific Ocean is characterized by a forested river canyon with riparian vegetation occurring along the channel. There is a greater diversity of riparian vegetation along the lower Klamath River below the mouth of the Trinity River, partly as a result of a more natural hydrograph on the Klamath River than exists on the Trinity River. Plant species composition changes as the Klamath River nears the Pacific Ocean; because the river slows, temperatures increase, and the tides affect salinity.

Grazing, timber harvest, and roads have degraded riparian conditions along the lower Klamath River (Yurok Tribe 2000). Riparian areas are dominated by deciduous trees including red alder. Red alder is a typical hardwood in riparian zones, tanoak is a typical hardwood on mid to upper slopes, and Pacific madrone occurs in small stands on drier sites (Green Diamond Resource Company 2006).

The broad lower Klamath River meanders within the floodplain and supports wetland habitats similar to those that existed pre-dam along the Trinity River. Wetland habitats along the lower Klamath River are dominated by cattails, tules, and a variety of rushes and sedges. As the river nears the ocean, salt-tolerant plants such as cord grass and pickleweed increase in abundance as the salinity increases (USFWS et al. 1999). Wildlife species in the lower Klamath River watershed are similar to those found in the Trinity River watershed.

10.3.3 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.

The Central Valley Region includes portions of the Sacramento Valley and San Joaquin Valley; including the Delta, Suisun Marsh, and the Yolo Bypass. The areas where terrestrial biological resources could potentially be affected include the fluctuation zones associated with reservoirs; river margins influenced by the magnitude, duration, and frequency of flows; and agricultural lands and refuges served by CVP and SWP water supplies.

The Central Valley Region is predominantly made up of lowlands and plains surrounded by foothills and tall mountains of the Coast Ranges to the west, the Cascade Range to the north, the Sierra Nevada Mountains to the east, and the Tehachapi Mountains to the south. Communities of various sizes and an extensive network of roadways are located throughout the valley.

Land use within the Sacramento Valley and San Joaquin Valley is dominated by agriculture and urban development. Grassland and oak woodland habitats occur in the foothills, particularly in the mid-elevation eastern margin of the Sacramento and San Joaquin valleys. Coniferous forests, mixed hardwood/coniferous forests, and oak woodlands generally represent the dominant vegetation surrounding CVP and SWP reservoirs. Riparian vegetation is generally constrained to narrow ribbons immediately adjacent to creeks and rivers. Many of the wetlands and riparian areas that once occurred in the Central Valley have been eliminated as a consequence of land use conversion to agriculture and urbanization.

10.3.3.1 Overview of Terrestrial Communities

This section describes the terrestrial communities in the Central Valley Region that could be affected directly or indirectly by operations of the CVP and SWP. These communities are broadly described for lakes/reservoirs (including open water and drawdown areas); rivers (including open water and riparian and floodplain areas); wetlands; and agricultural lands that could be affected by changes in water deliveries and ecosystem restoration activities. Other communities are described for areas that could be affected by restoration activities related to the proposed action and alternatives.

10.3.3.1.1 Lake/Reservoir Communities

Reservoirs that store CVP and SWP water supplies provide habitat used by some terrestrial species, either within the open water area of the reservoirs or along the margins and in the drawdown areas.

Open Water Areas

As described in Chapter 5, Surface Water Resources and Water Supplies, water surface elevations in reservoirs that store CVP and SWP water supplies change seasonally and annually due to hydrologic and operational variables. The open water areas of these reservoirs are used as foraging and resting sites by waterfowl and other birds, and by semi-aquatic mammals such as river otter and beaver. Bald Eagles and Ospreys nest in forests at the margins of these reservoirs, and frequently use the reservoirs to forage for fish.

Margin and Drawdown Areas

The CVP and SWP reservoirs in the Central Valley are generally located in canyons where the surrounding slopes are dominated by upland vegetation such as woodland, forest, and chaparral. The water surface elevations in these reservoirs fluctuate within the inundation area, as described in Chapter 5, Surface Water Resources and Water Supplies, between maximum allowed storage elevations and minimum elevations defined by the lowest elevation on the intake structure. Along the water surface edge of the inundation area, the soils are usually shallow. Soil is frequently lost to wave action and periodic inundation, followed by severe desiccation when the water elevation declines, which generally results in a barren drawdown zone around the perimeter of the reservoirs. Natural regeneration of vegetation within the drawdown zone is generally prevented by the timing of seed release when reservoir levels are high in the spring, lack of sediment replenishment necessary for seedling establishment in the spring, and high temperatures combined with low soil moisture levels of exposed soils in the summer.

Lack of vegetative cover within the drawdown zone can limit wildlife use of this area. Rapidly rising reservoir levels can potentially result in direct mortality of some sedentary wildlife species or life stages within the drawdown zone of reservoirs. As reservoir levels drop, energy expenditures can increase for piscivorous (fish-eating) birds foraging in the reservoirs as these species must travel greater distances to forage (DWR 2004a).

10.3.3.1.2 Riverine Communities

The rivers and streams influenced by the long-term coordinated operation of the CVP and SWP support habitats for plants and wildlife. The primary components of the riverine environment that support plants and wildlife, including open water areas and adjacent riparian and floodplain communities (including bypasses that are inundated at high flows), are described below.

Open Water Areas

The riverine environment downstream of reservoirs is managed generally for water supply and flood control purposes. As such, the extent of open water in the rivers varies somewhat predictably, although not substantially, within and among years. In the wetter years when bypasses and floodplains are inundated, vast areas of open water become available during the flood season, generally in the late winter and early spring. Open water portions of riverine systems provide foraging habitat for fish eating birds and waterfowl. Gull, Tern, Osprey, and Bald Eagle forage over open water. Near shore and shoreline areas provide foraging habitat for birds such as waterfowl, heron, egret, shorebirds, and belted kingfisher. Many species of insectivorous birds such as swallows, swifts, and flycatchers forage over open water areas of lakes and streams. Mammals known to associate with open water and shoreline habitats include river otter, American mink, muskrat, and beaver.

Riparian and Floodplain Areas

The riparian and floodplain communities that could be affected by CVP and SWP operations refers primarily to the vegetation and associated wildlife community supported and influenced by proximity to the waterway, including areas frequently flooded by rising water levels in the rivers (floodplains). The extent of riparian vegetation within the Central Valley has been reduced over time due to a variety of actions, including local, state, and Federal construction and operation of flood control facilities isolated historic floodplains; agricultural and land use development that occurred following development of flood control projects; regulation of flows from dams that has reduced the magnitude and frequency of larger flow events, increased recession rates, and increased summertime flows; and construction and maintenance of active ship channels by the U.S. Army Corps of Engineers (USACE) (DWR 2012). Currently, levee and bank protection structures associated with the flood protection system are present along more than 2,600 miles of rivers in the Central Valley, including the Delta (DWR 2009a).

Characteristic riparian tree species in the Central Valley include willows, cottonwoods, California sycamore, and valley oaks. Typical understory plants include elderberry, blackberries, and poison oak. On the valley floor in the deep alluvial soils, the structure and species composition of the plant communities change with distance from the river, with the denser stands of willow and cottonwood at the water’s edge transitioning into stands of valley oaks on the less frequently inundated terraces. In other areas, the riparian zone does not support a canopy of large trees and instead is dominated by shrub species (sometime referred to as riparian scrub).

Riparian and floodplain vegetation supports wildlife habitats because of its high floristic and structural diversity, high biomass and high food abundance, and proximity to water. In addition to providing breeding, foraging, and roosting habitat for an array of animals, riparian and floodplain vegetation also provides movement corridors for some species, connecting a variety of habitats throughout the region. The Sacramento and San Joaquin valleys lack substantial areas of natural habitat that support native biodiversity or corridors between the areas of natural habitat; therefore, riparian and floodplain corridors play a critical role in connecting wildlife among the few remaining natural areas (CalTrans and DFG 2010).

Typical wildlife species associated with the riparian and floodplain communities include mammals such as striped skunk, raccoon, and gray fox. Riparian bird species include Red-Shouldered Hawk, Wood Duck, Great Blue Heron, Black-Crowned Night Heron, and many neotropical migratory birds, including Yellow Warbler and Western Yellow-Billed Cuckoo. Amphibians and reptiles include Pacific Tree Frog, Pacific Gopher Snake, Garter Snake, and Western Pond Turtle. Special status species that associate with riparian and floodplain habitats include Bank Swallow (state listed), Western Yellow-Billed Cuckoo (Federally and state listed), and the Valley Elderberry Longhorn Beetle (Federally listed).

River flows and associated hydrologic and geomorphic processes are important for maintaining riparian and floodplain ecosystems. Most aspects of a flow regime (e.g., the magnitude, frequency, timing, duration, and sediment load) affect a variety of riparian and floodplain habitat processes. Two processes that create riparian and floodplain ecosystems are disturbance and plant recruitment. The interaction of these processes across the landscape is primarily responsible for the pattern and distribution of riparian and floodplain habitat structure and condition, and for the composition and abundance of riparian-associated species.

High flow events and associated scour, deposition, and prolonged inundation can create exposed substrate for plant establishment or openings in existing riparian and floodplain communities. Early successional species, like cottonwoods and willows that recruit into these openings, become more abundant in the landscape as vegetation grows within disturbed areas. As a result, structural and species diversity within riparian and floodplain vegetation could increase, as could overall wildlife habitat values. Without disturbance, larger trees and species less tolerant of frequent disturbance begin to dominate riparian woodlands.

The recruitment of cottonwoods and willows especially depends on geomorphic processes that create bare mineral soil through erosion and deposition of sediment along river channels and on floodplains, and on flow events that result in floodplain inundation. Receding flood flows that expose moist mineral soil create ideal conditions for germination of cottonwood and willow seedlings. After germination occurs, the water surface must decline gradually to enable seedling establishment. Riparian and floodplain communities also undergo natural disturbance cycles when flood flows remove streamside vegetation and redistribute sediments and seeds, thereby maintaining habitat diversity for terrestrial species that associate with riparian and floodplain corridors.

Both prolonged drought and prolonged inundation, however, can lead to plant death and loss of riparian plants (Kozlowski and Pallardy 2002). Riparian plants have high moisture requirements during the active growing season (spring through fall), and dry soil conditions can reduce growth and injure or kill plants. On the other hand, prolonged inundation creates anaerobic conditions that, during the active growing season, also can reduce growth, injure, or kill plants.

The continuation of riparian and floodplain communities is anticipated to change along levees within the federally authorized levee systems that have maintenance agreements with the USACE (including Delta levees along the Sacramento and San Joaquin rivers) and other levees that are eligible for the federal Rehabilitation and Inspection Program (Public Law 84-99). As described in Section 3.3.2.2 of Chapter 3, Description of Alternatives, the vegetation management policies of the USACE were changed in 2009 and 2010. Historically, the USACE allowed brush and small trees to be located on the waterside of federal flood management project levees if the vegetation would preserve, protect, and/or enhance natural resources, and/or protect rights of Native Americans, while maintaining the safety, structural integrity, and functionality of the levee (DWR 2011). After Hurricane Katrina in 2005, the USACE issued a policy and draft policy guidance to remove substantial vegetation from these levees throughout the nation (USACE 2009). In 2010, the USACE issued a draft policy guidance letter, *Draft Process for Requesting a Variance from Vegetation Standards for Levees and Floodwalls—75 Federal Register 6364-68* (USACE 2010) that included procedures for State and local agencies to request variances on a site-specific basis. DWR has been in negotiations with USACE to remove vegetation on the upper third of the waterside slope, top, and landside of the levees, and continue to allow vegetation on the lower two-thirds of the waterside slope of the levee and along benches above the water surface (DSC 2011). The effects of these changes have not become widespread at this time. Future conditions under these requirements are further described under the description of the No Action

Alternative in this chapter (see Section 10.4.2.1.3, Changes in River and Delta Floodplains).

10.3.3.1.3 Wetlands, Marshes, and Wet Meadows

Wetlands in the Central Valley can be characterized as perennial or seasonal with perennial wetlands further classified as tidal or non-tidal. Natural, non-tidal perennial wetlands are scattered along the Sacramento and San Joaquin rivers, typically in areas with slow moving backwaters. Management of wetlands, marshes, and wet meadows can include irrigation of open areas to support native herbaceous plants or cultivated species; periodic or continuous flooding to provide feeding and roosting sites for many wetland-associated birds; and either limited or no tilling or disturbance of the managed areas.

Managed seasonal wetlands on the west side of the Sacramento River generally occur between Willows and Dunnigan along the Colusa Basin Drain. Substantial portions of these managed wetland habitats occur at the flood bypasses, including the Yolo Bypass Wildlife Area and Fremont Weir, as a part of the Sacramento National Wildlife Refuge Complex, and around the Thermalito Afterbay (Reclamation 2010a). Both tidal and nontidal, perennial wetlands are found in the Delta and Suisun Marsh.

Perennial Non-tidal (Freshwater) Wetlands and Marshes

In the Sacramento and San Joaquin valleys and foothills, perennial non-tidal wetland habitats include freshwater emergent wetlands and wet meadows. Freshwater emergent wetlands, or marshes, are dominated by large, perennial herbaceous plants, particularly tules and cattails, which are generally restricted to shallow water. In marshes, vegetation structure and the number of species are strongly influenced by disturbance, changes in water levels, and the range of elevations present at a site. Wet meadows are similar to perennial freshwater wetlands in many regards; however, they are dominated by a greater variety of perennial plants such as rushes, sedges, and grasses than are found in freshwater wetlands. Perennial freshwater wetlands also provide ecological functions related to water quality and hydrology. These areas generally qualify as jurisdictional wetlands subject to U.S. Army Corps of Engineers jurisdiction under Sections 401 and 404 of the federal Clean Water Act.

Perennial freshwater wetlands are among the most productive wildlife habitat in California (CDFW 1988a). In the Sacramento and San Joaquin valleys and foothills, these wetlands support several sensitive amphibians, reptiles, birds, and mammals. Perennial freshwater wetlands also provide food, cover, and water for numerous species of wildlife. Wetlands in the Sacramento and San Joaquin valleys and foothills are especially important to migratory birds and wintering waterfowl.

Seasonal Wetlands

Natural seasonal wetlands occur in topographic depressions and swales that are seasonally saturated and exhibit hydric soils that support hydrophytic plant species. Natural seasonal wetlands are generally dominated by hydrophytic plants during the winter and spring months. Characteristic plant species in seasonal wetlands consist of both native and nonnative species. Native species include coyote thistle, toad rush, hyssop loosestrife, and foothill meadowfoam. Natural seasonal wetlands provide food, cover, and water for numerous common and special status species of wildlife that rely on wetlands for all or part of their life cycle. Like perennial wetlands, seasonal wetlands have been substantially reduced from their historical extent.

Numerous managed seasonal wetlands occur within the Sacramento Colusa, Sutter, Tisdale, and Yolo Bypasses and around the Thermalito Afterbay (Reclamation 2010a).

Managed marsh areas are intentionally flooded and managed during specific seasonal periods to enhance habitat values for specific wildlife species (CALFED 2000). Managed marsh areas are distributed largely in the northern, central, and western portions of the Delta, as well as in Suisun Marsh and the Yolo Bypass, Stone Lakes National Wildlife Refuge, Cosumnes River Preserve, and Suisun Marsh.

Perennial Tidal Wetlands and Open Water

In the Central Valley, tidal wetlands and open water are primarily found in the Delta and Suisun Marsh. Tidal wetlands are influenced by tidal movement of salt water from San Francisco Bay and inflow of freshwater from the Delta and smaller local watersheds. Tidal open water in the Delta is mainly freshwater habitat, with brackish and saline conditions occurring in the western Delta at times of high tides and low flows into the western Delta. It is freshwater in the Yolo Bypass and mainly brackish and saline in Suisun Marsh. Tidal mudflats occur as mostly unvegetated sediment deposits in the intertidal zone between the tidal wetland communities at its upper edge and the tidal perennial aquatic community at its lower edge. Tidal brackish wetlands exist from near Collinsville westward to the Carquinez Strait. Suisun Marsh is the largest contiguous brackish water marsh remaining on the North America west coast (Reclamation et al. 2011). Tidal freshwater marshes occur at the shallow, slow-moving or stagnant edges of freshwater waterways in the intertidal zone and are subject to frequent long duration flooding.

Salinity levels vary throughout the year and are influenced largely by inflow from the Delta (Reclamation et al. 2011). Tidal water in the Delta is mainly freshwater, with brackish and saline conditions occurring in the western Delta at times of high tides and low flows into the western Delta. Tidal marshes associated with the lower Yolo Bypass are freshwater, whereas they are mainly brackish and saline in Suisun Marsh where tidal brackish marshes exist from near Collinsville westward to the Carquinez Strait.

10.3.3.1.4 Agricultural Lands

Agricultural land uses and farming practices in the Central Valley provide habitats and resources for a variety of terrestrial species, including several Federal and state special status species. Agricultural lands are primarily found within the

Sacramento and San Joaquin valleys on the rich alluvial soils of the riverine floodplains. The distribution of seasonal crops varies annually and seasonally, depending on market forces and crop-rotation patterns. Some of the principal crop types and their value to wildlife are described below.

Crops in the Sacramento and San Joaquin valleys include grain and seed crops (e.g., barley and wheat), forage crops (e.g., hay and alfalfa), row crops (e.g., tomatoes, lettuce, sugar beets), cotton, orchards (e.g., almonds, walnuts, peaches, plums), and vineyards. There are also areas of irrigated pastureland throughout the Sacramento and San Joaquin valleys.

Grain and seed crops include wheat, barley, corn, and other annual grasses that are grown in dense stands. Most of the value for wildlife occurs during the early growing period because the later dense growth makes it difficult for wildlife to move through these fields. Following harvesting, waste grain is available to waterfowl and other birds, such as sandhill crane. Row crop and silage fields generally provide lesser value to wildlife than native cover types, but can support abundant populations of small mammals, such as California vole and western harvest mouse. These species attract predators such as snakes and raptors. Other reptile and bird species prey on the abundant insect populations found in row crop and silage fields.

Species generally associated with field and row crops include the Red-Winged Blackbird, Western Meadowlark, California Vole, Black-Tailed Jackrabbit, Western Harvest Mouse, Botta’s Pocket Gopher, Raccoon, Striped Skunk, and Virginia Opossum. Croplands also provide foraging habitat for many raptors including Swainson’s Hawk, Northern Harrier, Red-Tailed Hawk, and White-Tailed Kite.

Alfalfa is irrigated and intensively mowed such that vegetation structure varies with the growing, harvesting, and fallowing cycle. As a result, alfalfa supports some of the highest biodiversity amongst crops in California, second only to rice in agricultural habitat biodiversity (Hartman and Kyle 2010), with many species using alfalfa to forage, nest, rest, and hide. A wide range of species, including songbirds, swallows, bats, and many types of waterfowl and migratory birds feed on insects in alfalfa fields. Mammals such as gophers, mice, and rabbits feed directly on alfalfa. Larger herbivorous mammals, such as deer, antelope, and elk, frequent alfalfa fields, especially during dry or cold seasons. Hawks, eagles, migratory birds, coyotes, and mountain lions feed on the birds and rodents that feed on the alfalfa. Scavengers such as coyotes and vultures feed on carrion (Putnam et al. 2001).

Rice cultivation is also widespread in the Sacramento Valley. Rice fields provide surrogate wetland habitats and many wetland wildlife species use rice fields, especially waterfowl and shorebirds, and wading birds that forage on aquatic invertebrates and vertebrates such as crayfish and small fish. Foraging opportunities are provided by fish that become entrained in the irrigation canals that supply water to the rice fields and the crayfish that are found along canal banks and berms of the rice fields. Other wildlife species that use flooded rice fields include Giant Garter Snake and bullfrog. Ring-necked pheasant and Sandhill Cranes among others forage on post-harvest waste grain. The practice of flooding rice fields in winter to allow for decomposition of rice stubble, as opposed to burning, enhances the wildlife value of rice fields. Winter flooding provides loafing and foraging opportunities for a variety of birds, including waterfowl, cranes, herons, and egrets.

Orchards and vineyards, typically dominated by a single tree species, are grown in fertile areas that once supported diverse and productive habitats for wildlife. Orchards and vineyards generally provide relatively low wildlife value; however, some species of birds and mammals have adapted to orchard and vineyard habitats. Many have become "agricultural pests" which result in crop losses. Deer and rabbits browse on the trees while other wildlife such as squirrels and numerous birds feed on fruit or nuts. Cover crops grown under the trees provide a food source for wildlife that feed on seeds or herbaceous vegetation. Wildlife species reported to feed on nuts (almonds and walnuts) include Northern Flicker, Western Scrub-Jay, American Crow, Plain Titmouse, Brewer's Blackbird, House Finch, Gray Squirrel and California Ground Squirrel (DFG 1999a, 1999b, 1999c). Other fruit crops such as apples, cherries, figs, pears and prunes are also eaten by these same species and others such as Band-Tailed Pigeon, Yellow-Billed Magpie, Western Bluebird, American Robin, Varied Thrush, Northern Mockingbird, Cedar Waxwing, Yellow-Rumped Warbler, Black-Headed Grosbeak, Bullock's Oriole, Desert Cottontail, Gray Squirrel, coyote, black bear, raccoon, and Mule Deer. Evergreen orchards (citrus, olives, avocado) do not provide the food for wildlife that many of the deciduous fruit and nut trees provide. Mourning Dove and California Quail use orchard habitats for cover and nesting sites. Carnivores such as fox, bobcat, and coyote frequently use avocado orchards (Nogeire et al. 2013). Irrigated pastures are managed grasslands with a low structure of native herbaceous plants, cultivated species, or a mixture of both. Pastures are not typically tilled or disturbed frequently and provide breeding opportunities for ground-nesting birds, including waterfowl, Ring-Necked Pheasant, and Sandhill Crane if adequate residual vegetation is present. Flood irrigation of pastures provides feeding and roosting sites for many wetland-associated birds, including shorebirds, wading birds, gulls, waterfowl, and raptors. Large mammals such as deer, and elk graze in pastures when there is adequate escape cover adjacent to the open pasture. Burrowing species using irrigated pastures include California Ground Squirrel, Pocket Gophers, and Burrowing Owls. Pastures provide foraging habitat for grassland-foraging wildlife, such as coyote and fox, and raptors like the Northern Harrier, American Kestrel, and Red-Tailed Hawk.

In addition to the crop lands, the network of irrigation canals, drains, and reservoirs that convey water in the agricultural areas provide habitat for many species of wildlife, including species with special status. These conveyance features, particularly those that contain water throughout the growing season, typically support some of the plants and animals characteristic of riverine systems and riparian areas. While water flows through many of these facilities intermittently, these features can provide habitat for species, such as Giant Garter

Snake. Giant Garter Snake is frequently associated with the water conveyance systems that support rice cultivation.

10.3.3.1.5 Invasive Species

Invasive plants and wildlife are species that are not native to the region, persist without human assistance, and have serious impacts on the environment. They are termed “invasive” because they displace native species and alter habitat functions and values. Many invasive plant species are considered “noxious weeds” by governmental agencies such as the U.S. Department of Agriculture and California Department of Food and Agriculture. Numerous invasive plants have been introduced into the study area, and many have become established. The California Invasive Plant Council maintains a list of species that have been designated as invasive in California (CalIPC 2006).

According to the California Department of Fish and Wildlife’s aquatic invasive species management plan (DFG 2008), invasive species threaten the diversity or abundance of native species through competition for resources, predation, parasitism, hybridization with native populations, introduction of pathogens, or physical or chemical alteration of the invaded habitat. Unlike the native riparian flora, many invasive riparian species do not provide the food, shelter, and other habitat components on which many native fish and wildlife species depend. In addition to the ability to degrade wildlife habitat, many of these invasive trees and shrubs have the potential to harm human health and the economy by adversely affecting the ecosystem, flood protection systems, water delivery, recreation, and agriculture.

Changes in CVP and SWP operations would affect the wetted edges at CVP and SWP reservoirs, reservoirs that store CVP and SWP water supplies, and along the rivers downstream of the CVP and SWP reservoirs. Therefore, only those invasive plant species that are associated with the margins at these waterways would be likely to cause adverse effects on terrestrial biological resources. Examples of these species include tree-of-heaven, giant reed, purple loosestrife, perennial pepperweed, tamarisk, and red sesbania. In addition to the potential effects caused by changed water operations, invasive species have the potential to be introduced as part of construction of habitat restoration, or to colonize areas disturbed by restoration construction activities (e.g., yellow star thistle, perennial pepperweed, Spanish broom, Himalaya blackberry).

10.3.3.2 Sacramento Valley

The Sacramento Valley portion of the Central Valley Region considered in this EIS includes Shasta Lake, Keswick Reservoir, and the Sacramento River from Keswick Reservoir to the Delta. The Sacramento Valley also includes the lower Yuba River and the middle and lower portions of the Feather River and American River watersheds that are influenced by CVP and SWP operations, respectively.

Historically, the Sacramento Valley contained a mosaic of riverine, wetland, and riparian communities with terrestrial habitats consisting of perennial grassland and oak woodlands. With development of the Sacramento Valley, native habitats were converted to cultivated fields, pastures, residences, water impoundments, and flood-control structures. As a result, native habitats generally are restricted in their distribution and size and are highly fragmented.

A listing of wildlife and plant species with special status that occur or may occur in portions of the study area affected by the long-term coordinated operation of the CVP and SWP is provided in Appendix 10A.

The USFWS has approved a habitat conservation plan for the Natomas Basin/Metropolitan Air Park near Sacramento. Six other habitat conservation plans are being prepared in the Sacramento Valley, including programs for Butte County, Yuba-Sutter counties, Placer County, Yolo County, South Sacramento County, and Solano County.

10.3.3.2.1 Shasta Lake and Keswick Reservoir

The area in which Shasta Lake is situated is characterized by a variety of vegetation and wildlife habitats typical of transitional mixed woodland and low-elevation forest habitats (Reclamation 2013a). The majority of vegetation communities and wildlife habitats around Shasta Lake are tree-dominated, and include upland forests with associated mixed chaparral, riparian forests, and woodlands. Other wildlife habitats around the lake include annual grasslands and barren areas. Montane riparian, the dominant riparian vegetation type at and near Shasta Lake, also occurs as thin stringers and patches along most stream corridors tributary to Shasta Lake.

Wildlife species around Shasta Lake are those typically associated with tree-dominated habitats and chaparral (Reclamation 2013a). Mammals in these habitats include deer, rabbits, chipmunks, and squirrels. Mature trees provide nesting habitat for raptors such as the bald eagle and osprey. Hollow trees and logs provide denning sites for mammals such as the coyote and skunks, and cavities in mature trees are used by cavity-dwelling species such as the Acorn Woodpecker and California Myotis. Many amphibians and reptiles, including Ensatina, Western Skink, and Western Fence Lizard, inhabit the detrital layer of moist areas. Snakes, including the Western Rattlesnake and Sharp-Tailed Snake, also are found in these habitats.

Recently, 38 pairs of mating Bald Eagles were observed at Shasta Lake (USFS 2012).

Terrestrial resources around Keswick Reservoir are similar to those found at lower elevations around Shasta Lake. Otters, Gray Fox, coyote, bobcat, Osprey, and turtles occur along the Keswick Reservoir reach of the Sacramento River (BLM 2006). Historically, vegetation in this area of the watershed was harvested to provide fuel for mining smelters. Chaparral habitat, dominated by manzanita with intermittent oak, pine, and fir trees occur on the foothills above the reservoir. As described in Chapter 5, Surface Water Resources and Water Supplies, water elevations in Keswick Reservoir are relatively stable throughout the year.

10.3.3.2.2 Whiskeytown Lake and Clear Creek

Riparian communities within the Whiskeytown Unit of the Whiskeytown-Shasta-Trinity National Recreation Area, which includes Whiskeytown Reservoir, include the following species: grey pine, willow, white alder, dogwoods, Oregon ash, bigleaf maple, and Fremont and black cottonwood. Wild grape is also very common; other riparian shrubs include snowberry, California blackberry, toyon, buckeye, and button willow. Flowering herbaceous plants, cattails, sedges, rushes, and ferns make up the riparian understory. The riparian habitats are generally vigorous and well-vegetated, especially in the most favorable locations, such as canyons and stream bottoms (NPS 1999).

Riparian vegetation is limited to a narrow band along the channel margins in the confined canyon reaches of Clear Creek between Whiskeytown Dam and Clear Creek Bridge, where the alluvial section of the creek begins. Downstream of Clear Creek Bridge, where the valley widens, the channel becomes predominately alluvial, and floodplains and terraces allow riparian vegetation to be more extensive (CBDA 2004).

Fresh emergent wetlands occur throughout the entire reach of lower Clear Creek from Whiskeytown Dam to the Sacramento River. These wetlands are more prominent in the reach below Clear Creek Road Bridge where soils are deeper and the valley becomes wider and is subject to periodic flooding. Valley-foothill riparian is found primarily in the lower reaches of lower Clear Creek from Clear Creek Road Bridge to the Sacramento River. In addition, smaller linear patches occur scattered throughout the system up to Whiskeytown Dam (BLM and NPS 2008).

Due to the diversity of habitats present within the watershed, the areas adjacent to Whiskeytown Lake and lower Clear Creek support a diverse assemblage of wildlife species. More than 200 vertebrate species are known to occur within the Whiskeytown Unit of the Whiskeytown-Shasta-Trinity National Recreation Area, including at least 35 mammal species, 150 bird species, and 25 reptile and amphibian species (NPS 2014).

10.3.3.2.3 Sacramento River: Keswick Reservoir to the Delta

Release of flows from Shasta Dam changed the pre-dam flow patterns from high flows in the mid-spring during snow melt to high flows in the summer months, as described in Chapter 5, Surface Water Resources and Water Supplies. Consequently, in most years, the current flow regime precludes or substantially reduces opportunities for establishment of cottonwoods and willows; and the structure and composition of riparian vegetation has undergone change (Roberts et al. 2002). The extent of early-successional riparian communities (e.g., cottonwood forest) has been decreasing, while the extent of mid-successional communities (e.g., mixed riparian forest) has been increasing. Generally, these effects diminish with distance downstream because of the influence of inflows from tributaries, diversions, and flood bypasses (Reclamation 2013a).

Much of the Sacramento River from Shasta Dam to Redding is deeply entrenched in bedrock, which precludes development of extensive areas of riparian vegetation (Reclamation 2013a). The upper banks along these steep-sided, bedrock-constrained segments of the upper Sacramento River are characterized primarily by upland communities, including woodlands and chaparral. Outside the river corridor, other vegetation communities along the upper Sacramento River include riparian scrub, annual grassland, and agricultural lands.

The river corridor between Redding and Red Bluff once supported extensive areas of riparian vegetation (Reclamation 2013a). Agricultural and residential development has permanently removed much of the native and natural habitat. Riparian vegetation now occupies only a small portion of floodplains. Willow and blackberry scrub and cottonwood- and willow-dominated riparian communities are still present along active channels and on the lower flood terraces, whereas valley oak–dominated communities occur on higher flood terraces. Although riparian woodlands along the upper Sacramento River typically occur in narrow or discontinuous patches, they provide value for wildlife and support both common and special status species of birds, mammals, reptiles, amphibians, and invertebrates.

Portions of the adjacent land along the Sacramento River from Red Bluff to Hamilton City include substantial remnants of the pre-European Sacramento Valley historical riparian forest (Reclamation 2013a). Along the Sacramento River below Red Bluff, riparian vegetation is characterized by narrow linear stands of trees and shrubs, in single- to multiple-story canopies. These patches of riparian vegetation may be on or at the toe of levees. Riparian communities in this region include woodlands and riparian scrub.

From Red Bluff to Colusa, the Sacramento River contains point bars, islands, high and low terraces, instream woody cover, and early-successional riparian plant growth, reflecting river meander and erosional processes (Reclamation 2013a). Major physiographic features include floodplains, basins, terraces, active and remnant channels, and oxbow sloughs. These features sustain a diverse riparian community and support a wide range of wildlife species including raptors, waterfowl, and migratory and resident avian species, plus a variety of mammals, amphibians, and reptiles that inhabit both aquatic and upland habitats.

Downstream of Colusa, the Sacramento River channel changes from a dynamic and active meandering one to a confined, narrow channel (Reclamation 2013a). Surrounding agricultural lands encroach directly adjacent to the levees, which have cut the river off from most of its riparian corridor, especially on the eastern side of the river. Most of the levees in this reach are lined with riprap, allowing the river no erodible substrate and limiting the extent of riparian vegetation and riparian wildlife habitat.

10.3.3.2.4 Feather River

Antelope Lake, Lake Davis, and Frenchman Lake located in the Upper Feather River; Lake Oroville and Thermalito Forebay and Afterbay; and the lower Feather River are located within areas in the Feather River watershed that could be affected by changes in CVP and/or SWP operations. Downstream of Lake Oroville, the basin extends south and includes the drainage of the Yuba and Bear Rivers.

Upper Feather River Lakes

The Upper Feather River Lakes, including Antelope Lake, Lake Davis, and Frenchman Lake, are SWP facilities on the upper Feather River upstream of Lake Oroville. These lakes are part of the Plumas National Forest and provide habitat for raptor nesting and wintering areas, waterfowl nesting area, and deer movement area (DWR 2013a; Plumas County 2012). Deer movement and fawning areas also occur around Lake Davis.

Lake Oroville and Thermalito Complex

Lake Oroville is situated in the foothills on the western slope of the Sierra Nevada Mountains, about a mile downstream of the confluence of its major tributaries. Below the dam, a portion of the river flow is diverted at the Thermalito Diversion Dam and routed to the Thermalito Forebay, which is an offstream reservoir with a surface area up to 630 acres (DWR 2007a, 2007b). Downstream of the forebay, water is stored in Thermalito Afterbay (up to 4,300 surface acres), which among other purposes serves as a warming basin for agricultural water.

The majority of vegetation around Lake Oroville consists of a variety of native vegetation associations, including mixed oak woodlands, foothill pine/mixed oak woodlands, and oak/pine woodlands with a mosaic of chaparral (DWR 2004a, 2007a). Open areas within the woodlands consist of annual grassland species. Native riparian habitats are restricted to narrow strips along tributaries, consisting mostly of alder, willow, and occasional cottonwood and sycamore. There is minimum wetland vegetation around Lake Oroville, and most is associated with seeps and springs that are a natural part of the landscape above the high water line. Emergent wetlands are generally absent within the drawdown zone of Lake Oroville.

Lack of vegetative cover within the drawdown zone severely limits wildlife use of this area. Thirty-six wildlife species were detected using habitats within the drawdown zone on at least one occasion during field surveys (DWR 2004a). Several of these species may use habitats within the drawdown zone for reproduction including Belted Kingfisher, Canada Goose, Canyon Wren, American Dipper, killdeer, mallard, Common Merganser, and Northern Rough-Winged Swallow.

Riparian vegetation occurs around the north shore of Thermalito Forebay as a thin strip of mixed riparian species (mostly willows), with an understory of emergent wetland vegetation. Cottonwoods and willows occur in scattered areas around the high water surface elevation of Thermalito Afterbay shoreline (FERC 2007). Emergent wetlands ranging from thin strips to more extensive areas are found around Thermalito Forebay and Thermalito Afterbay. Waterfowl brood ponds constructed in inlets of Thermalito Afterbay support emergent vegetation along much of their shores.

Species observed within the wetland margin of Thermalito Afterbay include Barn Swallow, Black Phoebe, White-Tailed Kite, Black-Tailed Jackrabbit, Brown-Headed Cowbird, bullfrog, Common Garter Snake, Common Yellowthroat, Gopher Snake, Northern Harrier, Pacific tree Frog, raccoon, red-Winged Blackbird, Ring-Necked Pheasant, Short-Eared Owl, Striped Skunk, Tree Swallow, Virginia Opossum, and Violet-Green Swallow (DWR 2004a).

In contrast to the drawdown area around the margin of Lake Oroville, the drawdown zone of Thermalito Afterbay supports a richer wildlife community and greater habitat diversity. Survey data collected as part of the relicensing process indicate that exposed mudflats seasonally provide habitat for a variety of migratory waterbirds including Black-Necked Stilt, Black Tern, California Gull, Caspian Tern, Forster’s Tern, Greater Yellowlegs, Least Sandpiper, Long-Billed Dowitcher, Ring-Billed Gull, Semipalmated Sandpiper, Spotted Sandpiper, and White-Faced Ibis. Wading birds and other waterfowl have been observed on the mudflats as well as shallow flooded areas (DWR 2004a). Potentially suitable Giant Garter Snake habitat is present along portions of the afterbay and forebay margins. The existing waterfowl brood ponds provide a refuge for Giant Garter Snakes during periods of afterbay drawdown.

Several invasive plant species are found around Lake Oroville and downstream in and around the Thermalito Complex. Invasive species associated with riparian and wetland areas include purple loosestrife, giant reed, tree-of-heaven, and red sesbania. About 85 of the roughly 900 acres of wetlands and riparian areas along the margin of Thermalito Afterbay contain varying densities of purple loosestrife (DWR 2007a). Purple loosestrife adversely affects native vegetation.

Feather River from Oroville Complex to the Sacramento River

The Feather River from Oroville Dam to the confluence with the Sacramento River supports stands of riparian vegetation, which have been restricted over time by flood control levees and land clearing for agriculture and urbanization. As a consequence, the vegetation generally occurs in a narrow zone along much of the river in this reach. However, remnant riparian forest exist in areas where wide meander bends persist, such as at Abbott Lake and O’Connor Lake near the Lake of the Woods State Recreation Area (DWR 2004b). This area contains mixed riparian forests, including Fremont cottonwood, willow, boxelder, alder, and Oregon ash. The riparian strip along the river is bordered mostly by agricultural fields. Downstream of Yuba City near the confluence with the Sacramento River, valley oak and cottonwood riparian stands becomes more common.

As described above for the Sacramento River, riparian areas provide value for wildlife and support a wide range of species of birds, mammals, reptiles, amphibians, and invertebrates.

10.3.3.2.5 Yuba River

Portions of the Yuba River watershed along the North Yuba River between New Bullards Bar Reservoir and Englebright Lake and along the Lower Yuba River between Englebright Lake and the Feather River could be affected by operation of the Lower Yuba River Water Accord (DWR et al. 2007b).

New Bullards Bar Dam and Reservoir are owned and operated by the Yuba County Water Agency to provide flood control, water storage, and hydroelectric generation. The Harry L. Englebright Dam and Reservoir were constructed by the California Debris Commission downstream of New Bullards Bar Reservoir to trap and store sediment from historical hydraulic mining sites in the upper watershed, and to provide recreation and hydroelectric generation opportunities (USACE 2013). Following decommissioning of the California Debris Commission in 1986, administration of Englebright Dam and Reservoir (Lake) was assumed by the USACE. Portions of the watershed along the Middle Yuba River between New Bullards Bar Reservoir and Englebright Reservoir are within the Plumas and Tahoe national forests.

Vegetation communities adjacent to New Bullards Bar Reservoir include oak woodlands, mixed conifer, and montane hardwood habitats which include live oak, blue oak, foothill pine, California wild rose, and lupine (DWR et al. 2007). The shoreline is generally barren. Bald Eagles have been observed near New Bullards Bar Reservoir; and California Red-legged Frogs have been reported in a tributary to the reservoir, Oregon Creek.

Vegetation communities at Englebright Reservoir are generally blue oak woodland and montane chaparral with small areas of mixed chaparral and live oak woodland (Yuba County 2011).

Vegetation along the lower Yuba River downstream of Englebright Dam is characterized by a number of vegetation types including grasslands, woodlands, and chaparral (USACE 2014). Within the Narrows, a steep gorge in the Yuba River immediately below Englebright Dam, there is little vegetation; small, isolated clumps of willow, mulefat, and other riparian species are widely scattered along the mostly barren, rocky banks. Downstream of the Narrows, there are extensive piles of cobble and gravel left from past gold and gravel mining operations. Here there are narrow strips of riparian vegetation consisting of Fremont cottonwood, willow, boxelder, and elderberry shrub. As described above for the Sacramento River, these communities support a wide range of similar wildlife species including raptors, waterfowl, and migratory and resident avian species, plus a variety of mammals, amphibians, and reptiles that inhabit both aquatic and upland habitats.

10.3.3.2.6 Bear River

The Bear River flows into the Feather River downstream of the confluence with the Yuba River. As described in Chapter 5, Surface Water Resources and Water Supplies, the Bear River includes Nevada Irrigation District’s Rollins and Combie reservoirs along the upper and middle reaches of the Bear River, and South Sutter Water District’s Camp Far West Reservoir along the lower reach of the Bear River (FERC 2013; NID 2005).

Vegetation communities near the reservoirs and along the Bear River from Rollins Reservoir to the confluence with the Feather River occur in bands based on elevations (FERC 2013; NID 2005). Gray pine, ponderosa pine, hardwoods, and chaparral shrubs occur at the higher elevations with black cottonwood, white alder, and valley oak in the riparian zones. Incense cedar, Douglas fir, white fir, madrone, sugar pine, Brewer’s oak, whiteleaf manzanita, greenleaf manzanita, wedgeleaf ceanothus, deerbrush, and poison oak at mid-elevations with white alders, maple, and willow along the riparian areas.

10.3.3.2.7 American River

The American River watershed encompasses approximately 2,100 square miles (Reclamation et al. 2006). The North, Middle, and South forks of the American River converge upstream of Folsom Lake. Lake Natoma is located downstream of Folsom Lake. Water continues to flow between Nimbus Dam and the confluence with the Sacramento River, as described in Chapter 5, Surface Water Resources and Water Supplies.

Folsom Lake and Lake Natoma

Folsom Lake, formed by Folsom Dam, has a surface area of about 11,500 acres, and 75 miles of shoreline (Reclamation 2005a). Lake Natoma, which serves as an afterbay downstream of Folsom Dam, has about 540 acres of surface area.

Vegetation communities associated with Folsom Lake include oak woodland and annual grassland. The oak woodland habitat is located on the upland banks and slopes of the reservoir, and is dominated by live oak, blue oak, and foothill pine with several species of understory shrubs and forbs. Annual grasslands occur around the reservoir, primarily at the southern end.

The oak woodlands and annual grasslands around the reservoir support a variety of birds. A number of raptors, including red-tailed hawk, Cooper’s hawk, great horned owl, and long-eared owl use oak woodlands for nesting, foraging, and roosting. Mammal species likely to occur in woodland habitats include deer, coyote, bobcat, fox, Virginia Opossum, raccoon, rabbits, squirrels, and a variety of rodents. Amphibians and reptiles that may be found in oak woodlands include California Newt, Pacific Tree Frog, Western Fence Lizard, Gopher Snake, Common Kingsnake, and Western Rattlesnake. The adjacent grasslands are used by various bird species for foraging, including White-Crowned Sparrow, Lesser Goldfinch, Western Meadowlark, and several raptor species. Migratory waterfowl also are known to feed and rest in the grasslands associated with the north fork of Folsom Reservoir.

Seasonal wetland communities occur both inside and outside of the area influenced by the reservoir. These communities are exposed to wetland hydrology for a limited period of time and may not meet all criteria for wetlands. Within the reservoir drawdown zone, this seasonal vegetation is frequently inundated and may receive overland flow from upland areas. Outside of the drawdown zone, seasonally wet areas receive water from seeps, drainages, and precipitation (Reclamation et al. 2006). Small areas of permanent freshwater marsh are found at the toe of the Mormon Island Auxiliary Dam. Water birds and other wildlife depend on the freshwater marshes in these areas for foraging and/or rearing habitat. These species include Pacific Tree Frog, Western Toad, Common Garter Snake, beaver, raccoon, and muskrat.

Folsom Lake is surrounded by a relatively barren drawdown zone due to annual fluctuations in water elevations. The majority of this zone is devoid of vegetation, although scattered stands of woody vegetation occur in some areas of the drawdown zone (Reclamation et al. 2006). The only contiguous riparian vegetation occurs along Sweetwater Creek at the southern end of the reservoir.

Between Folsom Dam and Lake Natoma, the river channel is narrower and flanked by steep, rocky cliffs (Reclamation 2005a). The land along the river includes wooded canyon areas, sheer bluffs, and dredge tailings from the gold mining era. Within Lake Natoma, the open water is bordered by narrow bands of riparian woodland. Patches of permanent freshwater marsh exist in shallow coves that are inundated when water rises in Lake Natoma (Reclamation 2005a).

Lower American River between Lake Natoma and Confluence with the Sacramento River

Downstream of Lake Natoma, the lower American River flows to the confluence with the Sacramento River. In the upper reaches of the lower American River, the river channel is controlled by natural bluffs and terraces. Levees have been constructed along the northern and southern banks for approximately 13 miles upstream of the confluence with the Sacramento River (Reclamation et al. 2006).

Most of the lower American River is encompassed by the American River Parkway, which preserves what remains of the historic riparian zone (Reclamation et al. 2006). Vegetation communities along the lower American River downstream of Nimbus Dam include freshwater emergent wetland, riparian forest and scrub. Oak woodland and annual grassland are present in the upper, drier areas farther away from the river. The current distribution and structure of riparian communities along the river reflects the human-induced changes caused by activities such as gravel extraction, dam construction and operations, and levee construction and maintenance, as well as by both historical and ongoing streamflow and sediment regimes, and channel dynamics.

In general, willow and alder tend to occupy areas within the active channel of the river that are repeatedly disturbed by river flows, with cottonwood-willow thickets occupying the narrow belts along the active river channel (Reclamation et al. 2006). Typical species in these thickets include Fremont cottonwood, willow, poison oak, wild grape, blackberry, northern California black walnut, and white alder.

Cottonwood forest is found on the steep, moist banks along much of the river corridor (Reclamation et al. 2006). Valley oak woodlands occur on upper terraces where fine sediment and adequate soil moisture provide a long growing season. Live oak woodland occurs on the more arid and gravelly terraces that are isolated from the fluvial dynamics and moisture of the river. Annual grassland occurs in areas that have been disturbed by human activity and can be found in many areas within the river corridor.

The cottonwood-dominated riparian forest and areas associated with backwater and off-river ponds are highest in wildlife diversity and species richness relative to other river corridor habitats (Reclamation et al. 2006). More than 220 species of birds have been recorded along the lower American River and more than 60 species are known to nest in the riparian habitats. Typical species that can be found along the river include Great Blue Heron, Mallard, Red-Tailed Hawk, American Kestrel, California Quail, Killdeer, Belted Kingfisher, Western Scrub-Jay, Swallows, and American Robin. Additionally, more than 30 species of mammals reside along the river, including skunk, rabbit, raccoon, squirrel, vole, muskrat, deer, fox, and coyote. Reptiles and amphibians that occupy riparian habitats along the river include Western Toad, Pacific Tree Frog, bullfrog, Western Pond Turtle, Western Fence Lizard, Common Garter Snake, and Gopher Snake (Reclamation 2005a).

Backwater areas and off-river ponds are located throughout the length of the river, but occur predominantly at the Sacramento Bar, Arden Bar, Rossmoor Bar, and between Watt Avenue and Howe Avenue (Reclamation 2005a; Reclamation et al. 2006). Plant species that dominate these backwater areas include various species of willow, sedge, cattail, bulrush, and rush. Riparian vegetation around these ponded areas is composed of mixed-age willow, alder, and cottonwood. These backwater ponds may be connected to the river by surface water during high winter flood flows and by groundwater during other times of the year. Wildlife species typical of these areas include: Pied-Billed Grebe, American Bittern, Green Heron, Common Merganser, White-Tailed Kite, Wood Duck, Yellow Warbler, Warbling Vireo, Dusky-Footed Woodrat, Western Gray Squirrel, Pacific Tree Frog, and Western Toad.

Several non-native weed populations are rapidly expanding in the riparian vegetation of the lower American River (County of Sacramento 2008). In particular, red sesbania is expanding along shorelines of streams and ponds, along with other invasive species such as Chinese tallowtree, giant reed, pampasgrass, Spanish broom, Himalayan blackberry, and tamarisk, which can rapidly colonize exposed bar surfaces and stream banks.

10.3.3.2.8 Agricultural Lands in the Sacramento Valley

The study area in the Sacramento Valley includes Shasta, Plumas, Tehama, Glenn, Colusa, Butte, Sutter, Yuba, Nevada, Placer, El Dorado, Sacramento, Yolo, and Solano counties. As described in Chapter 12, Agricultural Resources, field and forage crops dominate the irrigated acreage in Sacramento Valley with over 1.4 million acres irrigated. Rice, irrigated pasture, and hay are the largest acreages. Second to field and forage crops are orchard and vine crops, making up roughly 21 percent of the total acreage. Almonds and walnuts are the largest acreages in this category. In total, the Sacramento Valley contains nearly two million agricultural acres. Typical terrestrial resources of these crops are described in subsection 10.3.4.1.4, Agricultural Lands.

10.3.3.2.9 Wildlife Refuges in the Sacramento Valley

The Sacramento Valley supported three major landscape types: wetlands, grassland-prairies, and riparian woodlands (Reclamation et al 2001a). These habitats were hydrologically and biologically linked to the river systems. Prior to their containment by the construction of dams and levees, the major rivers meandered, forming oxbows and riparian habitat. Winter floods would inundate and scour areas along these rivers, creating marshes and early-succession riparian scrub. Expanses of seasonal wetlands were also created by winter flooding. These seasonal wetlands formed habitat for overwintering and migrating waterfowl. Habitat areas such as wetlands are now intensively managed to support a wide range of birds and other wildlife within small and fragmented areas. Remnant wetlands and agricultural lands in the Central Valley support approximately 60 percent of the waterfowl wintering in the Pacific Flyway region (includes Alaska, Arizona, California, Idaho, Nevada, Oregon, Utah, Washington, and portions of Colorado, Montana, New Mexico, and Wyoming west of the Continental Divide [PFC 2014]). In addition, another 20 percent of the Pacific Flyway population passes through the Central Valley, using the wetlands for foraging and resting on their migratory passage through the region. The Sacramento Valley provides winter habitat for 44 percent of the Pacific Flyway waterfowl. The wetland and associated habitat are also important to several federally listed and proposed species, and other special status species such as the American Peregrine Falcon, Bald Eagle, Aleutian Canada Goose, Giant Garter Snake, and California Tiger Salamander.

The Sacramento National Wildlife Refuge (NWR) Complex is composed of five national wildlife refuges (Sacramento, Delevan, Colusa, Sutter and Sacramento River NWRs) and three state wildlife management areas (Willow Creek-Lurline, Butte Sink and North Central Valley Wildlife Management Areas) (USFWS 2013a). The refuges of the Sacramento NWR Complex contain permanent ponds, seasonal wetlands, irrigated moist soil impoundments, and uplands (Reclamation et al 2001). Gray Lodge Wildlife Area is located adjacent to the Butte Sink, an overflow area of Butte Creek and the Sacramento River. It consists of seasonal wetlands and upland areas with permanent wetland and riparian habitats (DFG 2011a). The Gray Lodge Wildlife Area supports permanent and seasonal wetlands, crops, and pasture (Reclamation et al. 2001).

Seasonally flooded marsh is the most prevalent and diverse of the wetland habitat types (Reclamation et al 2001). Wetland units managed as seasonally flooded marsh are typically flooded from early September through mid-April. Their diversity is the product of a variety of water depths that result in an array of vegetative species that, in combination, provide habitat for the greatest number of wildlife species throughout the course of a year. Through the fall and winter, seasonally flooded marshes are used by a wide range of waterfowl and smaller numbers of egret, heron, ibis, and grebe, to name a few. In addition, raptors take advantage of the water bird prey base. Water is removed in the spring; therefore, shorebirds use the shallow depth and exposed mudflats on their northern migration.

Moist soil impoundments, or seasonally flooded impoundments, are similar to seasonally flooded marshes (Reclamation et al 2001). Moist soil impoundments are typically irrigated during the summer to bolster plant growth and to enhance seed production. Irrigation is usually performed in mid-summer to increase plant biomass and seed production of watergrass, sprangletop, and smartweed plants. During these irrigation periods, these units are often used by locally nesting colonial water birds (egrets, herons).

Permanent ponds and summer water provide wetland habitat for year-round and summer resident species (Reclamation et al 2001). Permanent ponds remain flooded throughout the year, while units managed for summer water are flooded through June or July. Characterized by both emergent and submergent aquatic plants, permanent ponds and summer water units provide brood and molting areas for waterfowl, secure roosting and nesting sites for wading birds and other over-water nesters, and feeding areas for species like cormorants and pelicans. Permanent wetland habitats are also important to a number of special status species, such as the Giant Garter Snake, White-Faced Ibis, and Tricolored Blackbird.

Valley-foothill riparian habitats are found along low- to mid-elevation streams and waterways (Reclamation et al. 2001). Riparian habitats provide nesting, roosting, and feeding areas for passerines, raptors, herons, egrets, waterfowl, and small mammals. These areas also provide corridors for resident and migratory wildlife. Riparian woodland habitats are characterized by even-aged, broad-leafed, deciduous trees with open canopies that reflect flood-mediated episodic events. Cottonwood, willow, alder, and oak are typical trees found in riparian woodlands. Riparian scrub habitats are described as streamside thickets dominated by one or more willow species, as well as other fast-growing shrubs and vines.

10.3.3.3 San Joaquin Valley

The San Joaquin Valley portion of the Central Valley Region considered in this EIS includes the San Joaquin River from Millerton Lake to the Delta; lower Stanislaus River from New Melones Reservoir to the confluence with the San Joaquin River; San Luis Reservoir; and agricultural areas and wildlife refuges that use CVP and SWP water supplies.

Historically, the San Joaquin Valley was a large floodplain that supported vast expanses of permanent and seasonal marshes, lakes, and riparian areas. Almost 70 percent of the valley has been converted to irrigated agriculture (Reclamation 2005b). Relict stands of alkali desert scrub are widely scattered throughout the San Joaquin Valley, but are generally found in the Tulare Basin in the southern San Joaquin Valley. Annual and perennial grasslands occur throughout the San Joaquin Valley, mostly on level plains and the gently rolling foothills at elevations immediately higher than the patches of alkali desert scrub. Ruderal vegetation is typically associated with road and utility rights-of-way, borders of fields, ditches, and abandoned fields.

As described in subsection 10.3.2, Overview of Species with Special Status, A listing of wildlife and plant species with special status that occur or may occur in portions of the study area affected by the long-term coordinated operation of the CVP and SWP is provided in Appendix 10A.

The USFWS has approved a habitat conservation plan for San Joaquin County Multi-species Habitat Conservation and Open Space Plan, Kern Water Bank, and the Metropolitan Bakersfield.

10.3.3.3.1 San Joaquin River

Potential changes in CVP and SWP operations could affect terrestrial resources associated with the San Joaquin River from Millerton Lake to the Delta.

Millerton Lake

Millerton Lake on the San Joaquin River is located in the western foothills of the Sierra Nevada Mountains in an area that ranges from grasslands and rolling hills near Friant Dam, to steep, craggy slopes in the upper reaches of the lake. Vegetation around Millerton Lake consists of a number of terrestrial communities, including annual grassland, oak woodland, foothill pine oak woodland, and chaparral (Reclamation 2011; Reclamation and State Parks 2010).

The most dominant vegetation community near the water edge is the nonnative grassland with blue oak woodland on the slopes above the lake and mixed riparian woodlands along drainages to the lake (Reclamation 2011; Reclamation and State Parks 2010). The dominant grassland species include broad-leaf filaree, fiddleneck, Heermann tarweed, vinegar weed, and ripgut brome, soft chess, zorro grass. The blue oak woodland also includes gray pine, buck brush, bush lupine, holly-leaf redberry, and hoary coffeeberry. The mixed riparian woodland species include interior live oak and gray pine with red willow, Fremont cottonwood, California buckeye, edible fig, and Oregon ash with an understory of California grape, button bush, Himalayan blackberry, sedges, and nonnative spearmint. Aquatic plants occur along the drainages where the water is relatively stagnant including mosquito fern, common duckweed, dotted duckmeat, punctuate smartweed, tall flat sedge, and broad-leaf cattail. Much of the shoreline is barren or characterized by nonnative grasslands with weedy species, such as Bermuda grass and cocklebur, and sporadic Goodding’s black willow.

Mule Deer, California Quail, wild turkey, and feral pig, all of which are game species, occur in the area around Millerton Lake (Reclamation 2011; Reclamation and State Parks 2010). The region provides winter range and migratory routes for the San Joaquin deer herd. A number of special status bat species have potential to occur in the area, and suitable roost sites may be found throughout the area. Other special status species that may occur in the area include the ringtail, American badger, and San Joaquin pocket mouse.

A relatively diverse community of reptile and amphibian species exists in and around Millerton Lake (Reclamation 2011; Reclamation and State Parks 2010). The presence of the nonnative bullfrog has changed, and continues to dramatically alter, the extant reptile and amphibian community through predation and because of its ability to out-compete native species. The Western Pond Turtle is known to occur around the lake. The California Tiger Salamander has also been reported. Limited areas of potential breeding habitat for California tiger salamander, primarily stock ponds dominated by nonnative species, have been identified in the San Joaquin River gorge upstream of the lake.

Bald eagles use roost trees near open water for foraging and are known to winter around Millerton Lake (Reclamation 2011; Reclamation and State Parks 2010). Several species associated with riparian habitats, including the least Bell's vireo and willow flycatcher, occurred historically around the lake, but have not been recently documented. A number of nonnative birds, including European Starling and Brown-Headed Cowbird, influence the native bird community through competition and nest parasitism.

A number of rare and listed plant species are known to occur around Millerton Lake and the upper San Joaquin River (Reclamation 2011; Reclamation and State Parks 2010). These include Ewan's larkspur, Michael's piperia, tree anemone, and Madera leptosiphon. Two plant species which serve as hosts for special status invertebrates, the elderberry and California pipevine, are also known to occur in the area. California pipevine is the obligate host plant for the pipevine swallowtail, a butterfly species and the elderberry shrub is the host plant of the Valley Elderberry Longhorn Beetle.

San Joaquin River from Friant Dam to the Confluence with the Merced River

A multilayered riparian forest dominated by cottonwoods occurs on the active low floodplain of the San Joaquin River along with older stands of cottonwood-dominated riparian forest in areas that were formerly active floodplains prior to the completion of Friant Dam and associated diversion channels, and the resulting reduction in river flow (DWR and Reclamation 2002; Reclamation and DWR 2011). Other areas on the low floodplain are dominated by willow, with occasional scattered cottonwood, ash, or white alder. California buttonbush is often present and may even dominate the riverbank for stretches.

The intermediate terrace of the floodplain of the San Joaquin River is primarily a mixed-species riparian forest (DWR and Reclamation 2002; Reclamation and DWR 2011). Species dominance in this mixed riparian forest depends on site conditions, such as availability of groundwater and frequency of flooding. Typical dominant trees in the overstory and midstory include Fremont cottonwood, boxelder, Goodding's black willow, Oregon ash, and California sycamore. Immediately along the water's edge, white alder occurs in the upper reaches of the San Joaquin River. Typical shrubs include red willow, arroyo willow, and California buttonbush.

Tree-dominated habitats with an open-to-closed canopy are typically found on the higher portions of the floodplain (DWR and Reclamation 2002; Reclamation and DWR 2011). These areas are exposed to less flood-related disturbance than areas lower on the floodplain. Valley oak is the dominant tree species while California sycamore, Oregon ash, and Fremont cottonwood are present in small numbers.

Typical understory species include creeping wild rye, California wild rose, Himalayan blackberry, California wild grape, and California blackberry.

Dense stands of willow shrubs frequently occur within the active floodplain of the river in areas subject to more frequent scouring flows and often occupy stable sand and gravel point bars immediately above the active channel (DWR and Reclamation 2002; Reclamation and DWR 2011). Dominant species include sandbar willow, arroyo willow, and red willow. Occasional emergent Fremont cottonwood may also be present.

Other areas have vegetation consisting of woody shrubs and herbaceous species dominated by different species depending on river reach. Some areas are dominated by mugwort, together with stinging nettle and various tall weedy herbs. Other areas are dominated either by blackberry (usually the introduced Himalayan blackberry) or wild rose in dense thickets, with or without scattered small emergent willows.

Areas with fine-textured, rich alluvium located outside the active channels but in areas that are subject to periodic flooding contain a shrub-dominated community characterized by widely spaced blue elderberry shrubs (DWR and Reclamation 2002; Reclamation and DWR 2011). The herbaceous understory is typically dominated by nonnative grasses and forbs that are characteristic of annual grassland communities, including ripgut brome, foxtail fescue, foxtail barley, red-stemmed filaree, and horseweed.

Emergent wetlands typically occur in the river bottom immediately adjacent to the low-flow channel (DWR and Reclamation 2002; Reclamation and DWR 2011). Backwaters and sloughs where water is present through much of the year support emergent marsh vegetation, such as tule and cattails. More ephemeral wetlands, especially along the margins of the river and in swales adjacent to the river, support native and nonnative herbaceous species.

Prevalent invasive species found in this portion of the San Joaquin River corridor include red sesbania, tamarisk, giant reed, Chinese tallow, Tree-of-heaven, and perennial pepperweed (Reclamation and DWR 2011). Water hyacinth, water milfoil, Parrot’s feather, curly-leaf pondweed, and sponge plant occur within the streams, especially in areas with slow or ponded water.

The riparian forest trees and understory provide habitat for raptors, cavity-nesting birds, and songbirds, including Red-Tailed Hawk, Red-Shouldered Hawk, Swainson’s Hawk, White-Tailed Hawk, Downy Woodpecker, Wood Duck, Northern Flicker, Ash-Throated Flycatcher, Pacific-Slope Flycatcher, Olive Sided Flycatcher, Tree Swallow, Oak Titmouse, White-Breasted Nuthatch, Western Wood-Pewee, Warbling Vireo, Orange-Crowned Warbler, Yellow Warbler, Bullock’s Oriole, and Spotted Towhee (DWR and Reclamation 2002; Reclamation and DWR 2011). Western Wood-Pewee, Bushtit, Bewick’s Wren, Lazuli Bunting, Blue Grosbeak, and American Goldfinch inhabit the riparian scrub vegetation. Song Sparrow, Common Yellowthroat, Marsh Wren, and Red-Winged Blackbird inhabit the emergent wetlands. Coyote, River Otter, raccoon, Desert Cottontail, and Striped Skunk occur in the riparian forest and shrub communities. Shorebirds, such as Killdeer; Mallard Duck; California Vole; Common Muskrat; Norway Rat; Pacific Chorus Frog; Western Pond Turtle; and Western Terrestrial Garter Snake occur near the river.

San Joaquin River from Merced River to the Delta

Downstream of the Merced River confluence, vegetation and wildlife resources along the San Joaquin River are similar to the upstream reaches described above (DWR and Reclamation 2002; Reclamation and DWR 2011). The reach of the San Joaquin River immediately downstream of the Merced River is more incised than areas further downstream and has a less developed riparian area with less understory vegetation. Between the Merced River and the Delta, agricultural land use has encroached on the riparian areas, leaving only a narrow band of riparian habitat. Near the confluence with tributary rivers, in cutoff oxbows, and in the San Joaquin River NWR, there are more extensive riparian habitat areas. Remnant cattail-dominated marshes and tules occur in these areas.

Wildlife species are similar to those found in the reaches upstream of the Merced River described above (DWR and Reclamation 2002; Reclamation and DWR 2011).

10.3.3.3.2 Stanislaus River

The upper Stanislaus River watershed has a drainage area of approximately 980 square miles (Reclamation 2010b). The North, Middle, and South forks of the Stanislaus River converge upstream of the CVP New Melones Reservoir. Water from New Melones Reservoir flows into Tulloch Reservoir. Downstream of Tulloch Reservoir, the Stanislaus River flows to Goodwin Dam and then approximately 40 miles to the confluence with the San Joaquin River.

New Melones Reservoir

Several broad categories of vegetation have been described in other studies around the New Melones Reservoir, including blue oak woodland and blue oak-foothill pine woodland, grasslands, chaparral, wetlands, and serpentine-based communities (Reclamation 2010b). The montane hardwood and montane hardwood-conifer woodlands occur at higher elevations substantially above the reservoir open water, especially along the eastern portion of the New Melones Reservoir; and are not anticipated to be affected by changes in CVP and SWP operations.

Blue oak woodland vegetation occurs in the western and southwestern portion of New Melones Reservoir, especially on rocky slopes and along riparian corridors (Reclamation 2010b). Oak trees that are established along the shoreline during drier periods are frequently killed when the reservoir fills to the maximum elevation. The blue oak woodland community also includes ponderosa pine, California buckeye, manzanita, ceanothus, yerba santa, foothill pine, scrub oak, black oak, valley oak, interior live oak, coffeeberry, redberry, holly-leaved cherry, and needlegrass. The blue oak-foothill pine woodland occurs at higher elevations along the western and southern areas of the New Melones Reservoir, and includes understory species, including poison oak, woodland star, sugar cup, shooting star, Chinese house, and gooseberry. The oak woodland supports woodpecker, mourning doves, wild turkey, California quail, mule deer, black-tailed deer, western grey squirrel, gray fox, raccoon, feral pig, striped skunk, mountain lion, and bobcat. The transition chaparral zones between the oak woodlands and grasslands support California Thrasher, quail, wrentit, bobcat, Deer Mouse, feral pig, and Fence Lizard.

Annual grasslands occur along adjacent plains and foothills on the western and southern portions of New Melones Reservoir (Reclamation 2010b). The annual plant species, including wild oats, soft chess, ripgut, fiddleneck, longbeak stork's bill, and redstem stork's bill. Perennial grass species include triple-awned grass, wheat grass, bent grass, wild-rye, melic grass, needle-grass, and muhly. The area also includes foothill pine, blue oak, California poppy, and lupines. Grasslands support Meadowlark, Horned Lark, sparrow, quail, mouse, and vole. Raptors that forage in the grasslands include White-Tailed Kite, Northern Harrier, Great Horned Owl, Red-Tailed Hawk, and Swainson's Hawk.

Little riparian vegetation exists along the shoreline of New Melones Reservoir because fluctuating water levels limit the establishment of riparian vegetation (Reclamation 2010b). Riparian vegetation is generally found in the upstream reaches of some of the perennial drainages that flow into the reservoir. Wetland vegetation is found in some locations along the edges of the lake and in moist canyons. There are many riparian communities, seeps, and wet meadows in the upper reaches of streams that are tributaries of the lake. Species in the valley and foothill riparian woodlands include boxelder, Fremont cottonwood, willows, white alder, and big-leaf maple. The wet meadow species include short-hair sedge, gentian-aster, few-flowered spikerush, carpet clover, bentgrass, pull-up muhly, beaked sedge, Nebraska sedge, Kentucky bluegrass, longstalk clover, and tufted hairgrass.

The open water of New Melones Lake, along with associated shoreline vegetation, provides foraging and resting habitat for a variety of waterfowl and shorebirds (Reclamation 2010b). Several fish-eating bird species, such as grebe, forage in the open water; other species, such as ducks, herons, and egrets, dabble along the shoreline foraging on seeds and small fish in shallow areas. Trees along the shoreline provide nesting areas for osprey. Riparian areas along larger tributaries to New Melones Reservoir provide food, cover, water, and nesting habitat for a variety of wildlife species and serve as travel corridors for species such as black-tailed deer.

Limestone caves are located in portions of the upper reaches of New Melones Reservoir, especially along the Stanislaus River (Reclamation 2010b). Bats use the caves for roosting and breeding. A type of rare spider, New Melones harvestman, was transplanted from caves that were to be inundated through the filling of New Melones Reservoir into neighboring caves.

Tulloch Reservoir

Many vegetation community types characteristic of the New Melones Reservoir and other portions of the Sierra foothills are found around Tulloch Reservoir, including blue oak woodland, chaparral, grassland, various tree-shrub communities dominated by pines, and grasslands (Tri-Dam Project 2008). The elderberry shrub (*Sambucus* species) occurs at multiple locations around the reservoir and may provide habitat for the Valley Elderberry Longhorn Beetle. A number of nonnative weedy species have been documented around the reservoir including Himalayan blackberry, red brome, tree-of-heaven, slenderflower thistle, yellow star thistle, pampas grass, Bermuda grass, and the aquatic parrot's feather. The vegetation along the water edge is affected by daily and seasonal water elevation variability. Wildlife supported by the vegetative community are similar to wildlife communities near New Melones Reservoir as well as Western Pond Turtle, bat, river otter, and mink (Goodwin Power 2013).

Goodwin Dam

Downstream of Tulloch Dam, the Stanislaus River flows to Goodwin Dam, and then continues approximately 40 miles to the confluence with the San Joaquin River. Goodwin Dam serves as a diversion dam for Oakdale Irrigation District, South San Joaquin Irrigation District, and Stockton East Water District, as described in Chapter 5, Surface Water Resources and Water Supplies (Tri-Dam Project 2003, 2007). The Goodwin Dam impounds 502 acre-feet of water along the Stanislaus River approximately 1.6 miles downstream of Tulloch Dam and 8.3 miles downstream of New Melones Dam. Water surface elevations are relatively constant upstream of Goodwin Dam.

The vegetation communities in this area of the Stanislaus River are similar to the vegetation near Tulloch Dam, including hardwood and oak woodlands with blue oak, interior live oak, gray pine, California buckeye, toyon, tree of heaven, and California black walnut (Tri-Dam 2003). Near the Stanislaus River, the vegetation is characterized by riparian woodland with cottonwood, willows, white alder, blue elderberry, and Himalayan berry. Some low-gradient areas along the shoreline of Goodwin Lake, especially in coves, support small patches of emergent aquatic vegetation such as bulrush and cattail (Goodwin Power 2013). Wildlife occurrences are similar to conditions near Tulloch Reservoir.

Stanislaus River from Goodwin Dam to the Confluence with the San Joaquin River

From Goodwin Dam to Knight's Ferry, the Stanislaus River flows through a bedrock canyon with nearly vertical walls and rock outcrops (DFG 1995). The riparian edge includes valley foothill riparian vegetation in a very narrow band for the entire length of this reach. This habitat is characterized by a canopy layer of cottonwood, California sycamore, and valley oak. Subcanopy cover trees are white alder, boxelder, and Oregon ash. Typical understory shrub layer plants include wild grape, wild rose, California blackberry, elderberry, button brush, and willow. The herbaceous layer consists of sedges, rushes, grasses, miner's lettuce, poison-hemlock, and stinging nettle.

From Knights Ferry to the Orange Blossom Bridge, located to the east of the City of Oakdale, the valley foothill riparian habitat continues along the river (DFG 1995). Further away from the river, vegetation is dominated by blue oak-digger pine woodland and shrub, including California redbud, California buckeye, ceanothus, manzanita, poison oak, and grasslands. Vernal pools and vernal pool complexes are found within adjacent grasslands.

Downstream of the Orange Blossom Bridge, the riparian corridor is virtually nonexistent in some areas with agricultural land uses extending into the riparian corridor (DFG 1995). In a few areas the riparian corridor is wide, such as within Caswell Memorial State Park. The major habitats include valley foothill riparian along the Stanislaus River with annual grasslands and fresh emergent wetlands amount the agricultural and urban developments.

10.3.3.3.3 San Luis Reservoir Complex

The San Luis Reservoir complex, consisting of San Luis Reservoir, O'Neill Forebay, and Los Banos Creek Reservoir, is located in northwestern San Joaquin Valley and is part of the water storage and delivery system for the CVP and SWP. The area is located within several vegetative communities (Reclamation and State Parks 2013). The northern and western portion of the San Luis Reservoir is located within the coastal foothills with blue oak-foothill pine woodlands. The O'Neill Forebay and parts of Los Banos Creek Reservoir are located within the San Joaquin Valley with valley oak habitat.

The vegetation around the San Luis Reservoir complex and wildlife management areas consists of riparian woodlands, blue oak woodlands and savanna, coast live oak woodland, ornamental trees, California sagebrush scrub, grasslands, wetlands, alkali sink scrub, and nonnative and weedy plant communities (Reclamation and State Parks 2013). The riparian woodland and wetland communities occur at the edge of the reservoirs and along watercourses. The San Luis Wildlife Area also contains blue oak woodland, blue oak savanna, coast live oak woodland, and California sycamore riparian woodland. California sagebrush scrub occurs on hillsides above and to the west of Los Banos Creek Reservoir. Iodine bush scrub occurs at Salt Spring, a tributary to Los Banos Creek Reservoir. Native purple needlegrass occurs throughout the complex.

Along the shorelines, riparian vegetation remains in an early successional stage because either the extreme fluctuation of the water level inundates the vegetation or the vegetation does not receive enough water during the dry season (Reclamation and State Parks 2013). Areas at the edges of O'Neill Forebay and Los Banos Creek Reservoir appear to be slowly changing to riparian vegetation.

A herd of more than 200 tule elk occurs towards the western shoreline of San Luis Reservoir within and near Pacheco State Park (Reclamation and State Park 2013). The herd moves down towards the water edge within the reservoir inundation area when the water elevation is low. Another herd of approximately 60 individuals occur around B.F. Sisk Dam which forms San Luis Reservoir; and approximately 70 tule elk occur throughout other areas in the complex.

10.3.3.3.4 Agricultural Lands in the San Joaquin Valley

The study area in the San Joaquin Valley includes the counties of Stanislaus, Merced, Madera, San Joaquin, Fresno, Kings, Tulare, and Kern counties. As described in Chapter 12, Agricultural Resources, field and forage crops dominate the irrigated acreage in the San Joaquin Valley with over 5.5 million agricultural acres. Hay, cotton, and silage are the largest acreages. Second to field and forage crops are orchards and vineyards, making up roughly 35 percent of total acreage. Almonds and grapes are the largest acreages in this category.

Typical terrestrial resources of these crops are described in subsection 10.3.4.1.4, Agricultural Lands. In the grassland and pasture areas, areas not dominated by crops include nonnative grasses, foxtail barley, and forbs (Reclamation and DWR 2011). The grassland and pasture support Northern Harrier, Ring-Necked Pheasant, Mourning Dove, Burrowing Owl, Loggerhead Shrike, Deer Mouse, California Vole, California Ground Squirrel, Botta’s Pocket Gopher, American Badger, coyote, Western Toad, Western Fence Lizard, Western Racer, and Gopher Snake. The cropland provides foraging areas for raptors and supports Ground Squirrel, American Crow, Brewer’s Blackbird, and European Starling.

10.3.3.3.5 Wildlife Refuges in the San Joaquin Valley

The San Joaquin Valley historically supported three major landscape types: wetlands, grassland-prairies, and riparian woodlands (Reclamation et al 2001b). These habitats were hydrologically and biologically linked to the river systems. Prior to their containment by the construction of dams and levees, the major rivers meandered, forming oxbows and riparian habitat. Winter floods would inundate and scour areas along these rivers, creating marshes and early-succession riparian scrub. Expanses of seasonal wetlands were also created by winter flooding. These seasonal wetlands formed habitat for overwintering and migrating waterfowl. Habitat areas such as wetlands are now intensively managed to support a wide range of birds and other wildlife within small and fragmented areas. Remnant wetlands and agricultural lands in the Central Valley support approximately 60 percent of the waterfowl wintering in the Pacific Flyway region. In addition, another 20 percent of the Pacific Flyway population passes through the Central Valley, using the wetlands for foraging and resting on their migratory passage through the region. The Sacramento Valley provides winter habitat for 44 percent of the Pacific Flyway waterfowl. The wetland and associated habitat are also important to several federally listed and proposed species, and other special status species such as the American Peregrine Falcon, Bald Eagle, Aleutian Canada Goose, Giant Garter Snake, and California Tiger Salamander.

CVP water supplies are provided to the San Luis NWR Complex which includes the Merced NWR, San Luis NWR (including the San Luis Unit, West Bear Creek Unit, East Bear Creek Unit, Freitas Unit, Blue Goose Unit, and Kesterson Unit), and Grasslands Wildlife Management Area (Reclamation 2012; USFWS 2012b, 2013b). The San Luis NWR Complex also includes the San Joaquin River NWR which is influenced by CVP operations; however, this refuge does not specifically receive CVP water under a contract. CVP water supplies are also provided to the Los Banos Wildlife Area; Volta Wildlife Area; Mendota Wildlife Area; and North Grasslands Wildlife Area (including China Island Unit and Salt Slough Unit) (Reclamation 2012b). In the southern San Joaquin Valley, the Kern and Pixley NWRs provide wildlife viewing opportunities.

San Luis National Wildlife Refuge Complex

The San Luis NWR Complex includes wetlands, riparian forests, native grasslands, and vernal pools (USFWS 2012a, 2012b). The refuge is a major wintering ground and migratory stopover point for a wide range of waterfowl, shorebirds, and other waterbirds. The refuge is host to significant assemblages of birds, mammals, reptiles, amphibians, insects, and plants, some of which, such as the California Tiger Salamander and San Joaquin Kit Fox, are endangered species. Riparian woodlands occur along rivers and sloughs with willow, cottonwood, and oak to support egrets, herons, cormorants, raptors, and songbirds (USFWS 2012b). Wetlands occur on over 25 percent of the San Luis NWR Complex lands and provide nesting habitat for coots, grebes, blackbirds, bitterns, ibis, and marsh wrens; and seasonal wetlands for ducks, geese, shorebirds, and other waterbirds. Grasslands occur on over 70 percent of the lands, including the native creeping wild Rye and alkali sacaton, to support elk, Black-Tailed Deer, Desert Cottontail Rabbit, Black-Tailed Jackrabbit, voles, and songbirds. Vernal pools occur in some areas during the spring, especially in the Kesterson NWR and West Bear Creek Unit. Artificial dens and other habitat structures have been constructed on the refuge, including nest boxes for songbirds, owls, and wood ducks; and dens for kit foxes (USFWS 2012a).

San Luis National Wildlife Refuge

The San Luis NWR contains approximately 26,800 acres of wetlands, riparian forests, native grasslands, and vernal pools (USFWS 2012c). Saline and alkaline conditions on portions of the upland habitat support a rich botanical community of native bunchgrasses, native and nonnative annual grasses, forbs, and native shrubs. Wintering habitat is provided for numerous waterbirds, including green-winged teal, northern shoveler, mallard, gadwall, wigeon, cinnamon teal, northern pintail, ring-necked, canvasback, and ruddy ducks; snow, Ross', and white-fronted geese. Shorebirds include sandpipers and plovers. Tule elk occur in the upland habitats.

Merced National Wildlife Refuge

The Merced NWR contains approximately 10,250 acres of wetlands, native grasslands, vernal pools and riparian areas (USFWS 2012d). In addition to providing breeding habitat for Swainson's Hawk, Tricolored Blackbird, Marsh Wren, and Burrowing Owl; the refuge is host to the largest wintering populations along the Pacific flyway of Lesser Sandhill Crane and Ross' Goose. Mammals such as coyote, Ground Squirrel, rabbit, and beaver are found year-round. Vernal pools are a component of the refuge and are home to many species of vernal pool plants and invertebrates as well as the California Tiger Salamander. Merced NWR also includes approximately 300 acres of cultivated corn and winter wheat crops and more than 500 acres of irrigated pasture for wildlife.

San Joaquin River National Wildlife Refuge

The San Joaquin River NWR encompasses approximately 7,000 acres located where Tuolumne, Stanislaus, and San Joaquin rivers join, creating a mix of habitats for terrestrial wildlife and plan species. Initially established to protect and manage habitat for the Aleutian Cackling Goose, the refuge is currently managed to provide habitat for migratory birds and endangered wildlife species (USFWS 2012e, 2012f). The refuge includes a mosaic of valley oak riparian forest, riverine and slough habitats, seasonal and permanent wetlands, vernal pools, natural uplands, and agricultural fields. Over 500,000 native trees and shrubs such as willow, cottonwood, oak, blackberry, and rose have been planted across 2,200 acres of river floodplain within the refuge, creating the largest block of contiguous riparian woodland in the San Joaquin Valley. Endangered riparian brush rabbits have been re-introduced to this restored habitat from captive-reared populations. These woodlands also support a diversity of breeding songbirds including grosbeak, oriole, flycatcher, warbler, and Least Bell's Vireo; and a heron/egret rookery. The refuge also provides winter and migration habitat for Lesser Sandhill Cranes, Greater Sandhill Cranes, Snow Geese, Ross' Geese, and White-Fronted Goose.

Several nonnative invasive plants influence the quality of wildlife habitat on the refuge including yellow star thistle, perennial pepperweed, poison hemlock, Russian thistle, milk thistle, and bull thistle. According to the Comprehensive Conservation Plan for the refuge (USFWS 2006), infestations are greatest in fallow agricultural fields, roadsides, canal banks, and undergrazed pastures, as well as other disturbed sites. Perennial pepperweed is established throughout the riparian areas of the refuge and stands of giant reed are scattered along the banks of the San Joaquin River. Infestations of water hyacinth seasonally disrupt water delivery and create impenetrable surfaces in the streams, sloughs, oxbows, and canals.

Grasslands Wildlife Management Area

The Grasslands Wildlife Management Area is composed entirely of privately owned lands with perpetual conservation easements to preserve wetland and grassland habitats, and wildlife-friendly agricultural lands along the San Joaquin River (GRCD 2014; USFWS 2013c). The Grassland Resource Conservation District, located within the western portion of the Wildlife Management Area, contains approximately 75,000 acres of private wetlands and associated grasslands, and over 30,000 acres of federal National Wildlife Refuges and State Wildlife Management Area. The area constitutes 30 percent of the remaining wetland habitat in the Central Valley and is a major wintering ground for migratory waterfowl and shorebirds of the Pacific Flyway.

Grassland Resource Conservation District provides habitat for waterfowl, shorebirds, wading birds, songbirds, raptors, and other wildlife species (GRCD 2014; USFWS 2013c). The Grassland Resource Conservation District specifically manages a program to encourage production of natural food plants (such as swamp grass, smartweed, and watergrass). Habitats include seasonally flooded wetlands, moist soil impoundments, permanent wetland, irrigated pasture, and croplands.

Los Banos Wildlife Area

The Los Banos Wildlife Area, located approximately 4 miles northeast of Los Banos, contains more than 6,200 acres in the San Joaquin River floodplain and is dominated by seasonal wetlands (CDFW 2014a; Reclamation 2001b). Permanent and semi-permanent wetlands are also present, along with areas of riparian vegetation. The Los Banos Wildlife Area also supports native and nonnative grasslands. Irrigated pasture and croplands are maintained to provide food, resting, and nesting habitat for waterfowl and other wildlife. Western Pond Turtle, raccoon, Striped Skunk, beaver, muskrat, and mink; as well as over 200 species of waterfowl, shore birds, upland game birds, and song birds occur seasonally throughout the area. Seasonal marshes provide habitat for a wide range of waterbirds, upland birds, and seasonal migrants, including American bittern, snowy egret, killdeer, American avocet, wood duck, and mallard.

Volta Wildlife Area

The Volta Wildlife Area consists of approximately 2,900 acres. The Wildlife Area is partially in the Grassland Resource Conservation District (CDFW 2014b; Reclamation et al. 2001b). The Wildlife Area supports permanent and seasonal wetlands and valley alkali shrub. Irrigated pasture and crops are grown to provide food and nesting cover for migratory waterfowl. Beaver, coyote, cottontail, and 150 species of birds, including a wide range of waterfowl and shorebirds, are found on the Volta Wildlife Area.

Mendota Wildlife Area

The Mendota Wildlife Area contains more than 12,000 acres of flatlands and floodplain (Huddleston 2001; Reclamation et al. 2001b). The Mendota Wildlife Area has been managed primarily to provide seasonal wetland habitat. Water is used to irrigate natural food crops, such as swamp grass, alkali bulrush, smartweed, and millet, and to flood seasonal and semi-permanent wetlands. Small grains, corn, and pasture are also irrigated in the upland areas. The Wildlife Area has significant white-faced ibis and great-blue heron rookeries. Shorebirds, songbirds, raptors, waterfowl, and wading birds use the wetlands habitat. Mammals that use the refuge include coyote, muskrat, beaver, mink, raccoon, weasel, Black-Tailed jackrabbit, Cottontail Rabbit, Spotted Skunk, Striped Skunks, and Ground Squirrel.

North Grasslands Wildlife Area

The North Grasslands Wildlife Area includes the China Island, Salt Slough, and Galdwall units which encompass 7,069 acres of wetlands, riparian habitat, and uplands (CDFW 2014c). Restoration and enhancement actions have focused on increasing seasonal wetlands, permanent and semi-permanent wetlands, and riparian habitat on the unit, including habitat for the Swainson’s hawk and sandhill crane.

The China Island Unit of the North Grasslands Wildlife Area borders the San Joaquin River southwest of the confluence with the Merced River (DFG 2011b). The Salt Slough Unit is located on the west side of Salt Slough, adjacent to the San Luis NWR Complex and Los Banos Wildlife Area. Before its acquisition, the unit consisted mainly of irrigated pasture and was managed as a cattle ranch (DFG 2011c). Habitat on both units includes permanent wetlands that are flooded continuously; semi-permanent wetlands that are flooded in the spring and summer; moist soil vegetation to produce seeds and sustain invertebrates, including swamp timothy, watergrass, and smartweed; seasonal wetlands to provided flooded areas in the fall for waterfowl; riparian habitat, nesting habitat for resident breeding birds, including Short-Eared Owl, Northern Harrier, ducks, and pheasants; upland foraging areas; and pasture which provides late winter and early spring habitat for geese, and other habitat areas for sandhill crane, pheasants, and raptors.

Kern National Wildlife Refuge Complex

The Kern NWR Complex consists of the Kern NWR and Pixley NWR (USFWS 2013d). The Kern NWR contains approximately 11,249 acres including seasonal marsh; moist soil units; and uplands (e.g., grasslands, alkali playa, and valley sink scrub) (USFWS 2013e). Wetlands on the refuge are seasonal in nature. Fall flooding begins in mid-August, with a peak in flooded marsh habitat by January. This habitat is maintained through February, after which the wetland areas are slowly drained. Selected units are irrigated during late spring and early summer to encourage plants to grow, to provide food for wintering and migrating birds the following fall (USFWS 2013e). The refuge is the largest wetland area in the Southern San Joaquin Valley and plays a vital role in the Pacific Flyway for migrating waterfowl, shorebirds, and songbirds. Uplands occupy the northeastern and northwestern portions of the refuge, used by threatened and endangered species, such as San Joaquin Kit Fox, Tipton Kangaroo Rat, and Blunt-Nosed Leopard Lizard. Artificial dens have been built for endangered San Joaquin Kit Foxes and artificial burrows have been provided for Burrowing Owls.

The Pixley NWR contains 6,389 acres of grasslands, vernal pools, and playas along the historic Tulare Lake boundaries (USFWS 2014ak). The refuge includes approximately 300 acres of managed wetlands for waterfowl and shorebirds. San Joaquin Kit Fox, Blunt-Nosed Leopard Lizard, and Tipton Kangaroo rat use the upland areas. Vernal pools also occur on the refuge.

10.3.3.4 Delta, Suisun Marsh, and Yolo Bypass

Historically, the natural Delta system was formed by water inflows from upstream tributaries in the Delta watershed and outflow to Suisun Bay and San Francisco Bay (SFEI 2012). Upstream of the Delta, during high Sacramento River flows, water spilled into the geologic formation known as the Yolo Basin which extends from Knights Landing Ridge upstream of the confluence between the Sacramento and Feather rivers to the confluence of Cache Slough and the Sacramento River in the Delta upstream of Rio Vista and Suisun Marsh. The Delta and Suisun Marsh have a complex web of channels and islands and is located at the confluence of the Sacramento and San Joaquin rivers. As described below in subsection 10.3.4.4.1, Yolo Bypass, is a 59,280-acre floodway through the Yolo Basin that was constructed as part of the Sacramento River Flood Control Project to protect the cities of Sacramento and West Sacramento and the north Delta from extreme flood events.

The Delta (as legally defined in the Johnston-Baker-Andal-Boatwright Delta Protection Act of 1992 [California Water Code section 12220]) covers 737,358 acres, including 4,278 acres of the Suisun Marsh and 16,762 acres of the Yolo Bypass. Individually, the overall Delta, Suisun Marsh, and Yolo Bypass extend over 737,358 acres, 106,511 acres, and 59,280 acres, respectively. In total, the Delta, Suisun Marsh, and Yolo Bypass constitute a natural floodplain that covers approximately 882,200 acres and drains approximately 40 percent of the state (DWR 2009a).

As described in subsection 10.3.2, Overview of Species with Special Status, A listing of wildlife and plant species with special status that occur or may occur in portions of the study area affected by the long-term coordinated operation of the CVP and SWP is provided in Appendix 10A.

10.3.3.4.1 Delta and Suisun Marsh

The Delta overlies the western portions of the Sacramento River and San Joaquin River watersheds. The Delta is a network of islands, channels, and marshland at the confluence of the Sacramento and San Joaquin rivers. Major rivers entering the Delta are the Sacramento River flowing from the north, the San Joaquin River flowing from the south, and eastside tributaries (Cosumnes, Mokelumne, and Calaveras rivers). Suisun Marsh is a tidally influenced brackish marsh located about 35 miles northeast of San Francisco in southern Solano County It is a critical part of the San Francisco Bay/Sacramento–San Joaquin Delta (Bay-Delta) estuary ecosystem. The Delta, together with Suisun Marsh and greater San Francisco Bay, make up the largest estuary on the west coast of North and South America (DWR 2009a).

The Delta was once composed of extensive freshwater and brackish marshes, with tules and cattails, broad riparian thickets of scrub willows, buttonwillow, and native brambles. In addition, there were extensive riparian forests of Fremont cottonwood, valley oak, Oregon ash, boxelder, white alder, and Goodding’s black willow. Upland, non-riparian stands of valley oak and coast live oak occurred in a mosaic with seasonally flooded herbaceous vegetation, including vernal pools and alkali wetlands (SFEI 2012).

Substantial areas of the Delta and Suisun Marsh have been modified by agricultural, urban and suburban, and recreational land uses (Reclamation et al. 2011; SFEI 2012). Over the past 150 years, levees were constructed in the Delta and Suisun Marsh to provide lands for agricultural, municipal, industrial, and recreational land uses. The remaining natural vegetation is fragmented, and largely restricted to the edges of waterways, flooded islands, and small protected areas such as parks, wildlife areas, and nature reserves (Hickson and Keeler-Wolf 2007). A substantial portion of the emergent wetlands exists as thin strips along the margins of constructed levees (SFEI 2012). Current habitat along the Delta waterways includes seasonal wetlands, tidal wetlands, managed wetlands, riparian forests, and riparian scrub.

Seasonal wetlands historically had occurred along the riparian corridor at elevations that were inundated during high flow events. Many of the levees were constructed along the riparian corridor edges; and therefore, historic seasonal wetlands were substantially modified (SFEI 2012). Adjacent areas of perennial wetlands on the water-side of the riparian corridor were modified as levees were constructed and channels enlarged. In many of these areas the perennial wetlands were replaced by seasonal wetlands. The vegetation of seasonal wetlands is typically composed of wetland generalist species that occur in frequently disturbed sites such as hyssop loosestrife, cocklebur, dallis grass, Bermuda grass, barnyard grass, and Italian ryegrass.

Alkali-related habitats occur near salt-influenced seasonal and perennial wetlands. Alkali seasonal wetlands occur on fine-textured soils that contain relatively high concentrations of dissolved salts. These types of soils are typically found at the historical locations of seasonal ponds in the Yolo Basin in and around the CDFW Tule Ranch Preserve, and upland in seasonal drainages that receive salts in runoff from upslope salt-bearing bedrock such as areas near Suisun Marsh and the Clifton Court Forebay. Alkali wetlands include saltgrass, alkali weed, saltbush, alkali heath, and iodine bush. Small stands of alkali sink scrub (also known as valley sink scrub) are characterized by iodine bush.

Tidal wetlands consist of tidal brackish wetlands that occur either as relatively substantial tracts of complex tidal wetlands, or in narrow bands of fringing tidal wetlands (Siegel et al. 2010a). Fringing tidal marsh exists along the outboard side exterior levees and generally has formed since diking for managed wetlands began. Fringing tidal wetlands vary in size and vegetation composition, exhibit less geomorphic complexity, and have a low area-to-edge ratio. Fringing marshes lack connection with the upland transition, are often found in small, discontinuous segments, and can limit movement of terrestrial marsh species.

Plant zones in complex tidal wetlands are influenced by inundation regime and salinity. Tidal wetlands can be divided into three zones: low marsh, middle marsh, and high marsh (Reclamation et al. 2011). The low tidal wetland zone is tidally inundated once or twice per day. At the lowest elevations, vegetation is inhibited by frequent, prolonged, often deep inundation and by disturbance by waves or currents. The dominant plant species are bulrushes. Other species occurring in the low tidal wetland zone are pickleweed, lowclub rush, common reed, and cattails. The low tidal wetland zone provides foraging habitat for waterfowl and shorebirds, California Ridgway's Rail, California Black Rail, and other wading birds.

The middle tidal wetland zone is tidally inundated at least once per day; there is relatively little cover and no refuge from higher tides, which completely flood the vegetation of the middle marsh. The dominant plant species are pickleweed, saltgrass, and bulrush. Other species occurring in the middle tidal marsh are fleshy jaumea, sea milkwort, rushes, salt marsh dodder, alkali heath, cattail, sneezeweed, and marsh gumplant (Siegel et al. 2010b). The middle tidal wetland zone provides foraging habitat for salt marsh harvest mouse and Suisun shrew, as well as common and special status bird species, including waterfowl and shorebirds, California Ridgway's Rail, California Black Rail, and other wading birds. This zone also provides nesting and foraging habitat for Suisun Song Sparrow and Salt Marsh Common Yellowthroat (Reclamation et al. 2011).

The high tidal wetland zone receives intermittent inundation during the monthly tidal cycle, with the higher elevations being inundated during only the highest tides. Historically, the high marsh was an expansive transitional zone between the tidal wetlands and adjacent uplands. The high marsh and associated upland transition zone have been significantly affected by land use changes (e.g., managed wetlands, agriculture). The dominant plants are native species, such as saltgrass, pickleweed, and Baltic rush, and nonnative species, including perennial pepperweed, poison hemlock, and fennel. Other species occurring in the high tidal marsh are saltmarsh dodder, fleshy jaumea, seaside arrowgrass, alkali heath, brass button, and rabbitsfoot grass.

The high tidal marsh provides habitat for special status plants, including Suisun Marsh aster, Soft bird’s beak, and Suisun thistle (Siegel et al. 2010b). The high marsh zone provides foraging and nesting habitat for waterfowl, shorebirds, California Ridgway's Rail, California Black Rail, and other birds. It also provides foraging and nesting habitat for special status species such as Salt Marsh Harvest Mouse and Suisun Shrew and provides escape cover for Salt Marsh Harvest Mouse, and Suisun Shrew during periods when the middle and lower portions of the high tidal wetland zone are inundated (Reclamation et al. 2011).

Managed wetlands are primarily located within the Suisun Marsh, Cache Slough, and near the confluence of the Mokelumne and Sacramento rivers within the historical limits of the high tidal marsh and adjacent uplands that were diked and leveled for agricultural purposes and later managed to enhance habitat values for specific wildlife species (CALFED 2000). Diked managed wetlands and uplands are the most typical land cover type in the Suisun Marsh area. Managed wetlands are considered seasonal wetlands because they may be flooded and drained several times throughout the year. Watergrass and smartweed are typically the dominant species in managed wetlands that use fresher water. Bulrush, cattail, and tule are the dominant species in managed wetlands that employ late drawdown management. Pickleweed, fat hen, and brass buttons are typical in the higher elevations of the managed wetlands. In marshes with higher soil salinity, pickleweed, saltgrass, and other salt-tolerant species are dominant. Managed wetlands are managed specifically as habitat for wintering waterfowl species, including Northern Pintail, Mallard, American Wigeon, Green-Winged Teal, Northern Shoveler, Gadwall, Cinnamon Teal, Ruddy, and Canvasback ducks; White-Fronted Goose, and Canada Goose. Some wetlands are also managed for breeding waterfowl, especially mallard.

Riparian forest areas (excluding willow-dominated riparian habitats) are still present in some portions of the Delta along many of the major and minor waterways, oxbows, and levees (CALFED 2000). Riparian forest and woodland communities dominated by tree species are mostly limited to narrow bands along sloughs, channels, rivers, and other freshwater features throughout the Delta. Isolated patches of riparian vegetation are also found on the interior of reclaimed Delta islands, along drainage channels, along pond margins, and in abandoned, low-lying fields. Cottonwoods and willows, Oregon ash, boxelder, and California sycamore, are the most typical riparian trees in central California. Valley oak and black walnut are typical in riparian areas in the Delta. Riparian trees are used for nesting, foraging, and protective cover by many bird species and riparian canopies provide nesting and foraging habitat for a variety of mammals. Understory shrubs provide cover for ground-nesting birds that forage among the vegetation and leaf litter.

Riparian scrub in the Delta and Suisun Marsh consists of woody riparian shrubs in dense thickets (SFEI 2012). Riparian scrub thickets are usually associated with higher, sloping, better drained edges of marshes or topographic high areas, such as levee remnants and elevated flood deposits; and along shorelines of ponds or banks of channels in tidal or non-tidal freshwater habitats. Plant species may include willow, blackberry, buttonbush, mulefat, and other shrub species. Willow-dominated habitat types appear to be increasing in extent in recent years; and willows line many miles of artificial levees where waterways historically had flowed into freshwater emergent wetland. Nonnative Himalayan blackberry thickets are a typical element of riparian scrub communities along levees and throughout pastures in the levees. Willow thickets provide habitat for a wide range of wildlife species, including the Song Sparrow, Lazuli Bunting, and Valley Elderberry Longhorn Beetle.

10.3.3.4.2 Yolo Bypass

The Yolo Bypass is a 59,280-acre floodway through the natural-overflow of the Yolo Basin on the west side of the Sacramento River (DWR 2012). As described in Chapter 5, Surface Water Resources and Water Supplies, the Yolo Bypass generally extends north to south from Fremont Weir along the Sacramento River (near Verona) to upstream of Rio Vista along the Sacramento River in the Delta. The bypass, part of the Sacramento River Flood Control Project, conveys floodwaters around the Sacramento River near the cities of Sacramento and West Sacramento. The bypass is utilized as a flood bypass approximately once every 3 years, generally during the period from November to April. Land use in the Yolo Bypass is generally restricted to specific agriculture, managed wetlands, and vegetation communities to ensure that floodway function is maintained (CALFED et al. 2001; USFWS 2002). Agricultural crops include corn, tomatoes, melons, safflower, and rice within the northern bypass; and corn, milo, safflower, beans, tomatoes, and sudan grass in the southern bypass. Waterfowl hunting areas are generally located in the southern bypass, and include rice fields, permanent open water, or a mixture of water and upland habitat. The USACE has developed criteria for managing emergent vegetation (e.g., cattails and bulrushes) in the Yolo Bypass to maintain flood capacity, including no more than 5 percent of the vegetation in seasonal wetlands can be emergent wetlands; no more than 50 percent of the vegetation in permanent wetlands can be emergent wetlands; and riparian vegetation can only occur in specified areas to maintain flood capacity (DFG and Yolo Basin Foundation 2008).

The Yolo Bypass supports several major terrestrial vegetation types, including riparian woodland, valley oak woodland, open water, and wetland. Historically, riparian woodland and freshwater wetland were the dominant habitat types in the Yolo Basin (CALFED et al. 2001; USFWS 2002). Currently, riparian woodland and associated riparian scrub habitats are primarily found adjacent to Green's Lake, Putah Creek, and along the East Toe Drain within the Yolo Bypass Wildlife Area. Riparian woodland is a tree-dominated community found adjacent to riparian scrub on older river terraces where flooding frequency and duration is less. Riparian woodlands include Fremont cottonwood, valley oak, sycamore, willow, eucalyptus, giant reed, and black oak. The understory is typically sparse in this community with limited areas of California grape, blackberry, poison oak, mugwort, grasses, and forbs. The woodland canopy provides habitat for hawks, owls, American Crow, Great Egret, Great Blue Heron, Red-Tailed Kite, Yellow-Rumped Warbler, Black Phoebe, woodpecker, Wood Duck, bat, and raccoon.

Riparian scrub is a shrub-dominated community typically found along stream margins and in the streambed, on gravel bars and similar formations (CALFED et al. 2001; USFWS 2002). This community is typically dominated by phreatophytes (i.e., deep-rooted plants that obtain their water from the water table or the layer of soil just above it), such as willows, and other plants representative of early- to mid-successional stage vegetation communities within riparian areas in the Central Valley. The species include alder, elderberry, cottonwood, wild rose, blackberry, and boxelder. This habitat supports Black-Crowned Night Heron, Snowy Egret, Belted Kingfisher, Black Phoebe, Swallow, and bat. Riparian scrub habitat frequently occurs adjacent to nonwoody riparian habitat, including false bamboo, cocklebur, weedy annual grasses, sedges, rushes, mustard, sweet clover, thistle, and other weedy species. The nonwoody riparian habitat supports Savannah Sparrow, House Finch, American Goldfinch, California Ground Squirrel, Gopher Snake, and pond turtle.

Remnants of valley oak woodlands and savanna occur on floodplain terraces in fragmented areas, including downstream of Fremont Weir and along the southern portion of the Toe Drain (CALFED et al. 2001). The habitat also includes sycamore, black walnut, wild grape, poison oak, elderberry, blackberry, grass, and sedge.

Depending on the duration of inundation, local soil factors, site history, and other characteristics, seasonal wetlands typically are dominated by species characteristic of one of three natural wetland communities: freshwater marshes, alkali marshes, or freshwater seasonal (often disturbed) wetlands (CALFED et al. 2001). Freshwater marsh communities are typically found in areas subjected to prolonged flooding during the winter months, and frequently do not dry down until early summer. Permanent open water is found throughout the Yolo Bypass, including Gray's Bend near Fremont Weir, Green's Lake near Interstate 80, ponds in the Yolo Bypass Wildlife Area, along Cache and Prospect sloughs, and within canals and drainage ditches. The wetlands support duck breeding habitat; and habitat for many lifestages of grebe, ibis, heron, egret, bittern, coot, rails, raptors, muskrat, raccoon, opossum, beaver, Ring-Necked Pheasant, garter snake, Pacific Tree Frog, and bullfrog.

Managed wetlands in the Yolo Bypass occur near Fremont Weir, in the 16,770-acre Yolo Bypass Wildlife Area, and within and near Cache Slough. The managed wetlands are generally flooded in the fall, with standing water maintained continuously throughout the winter until drawdown occurs in the following spring (CALFED et al. 2001; DFG and Yolo Basin Foundation 2008). A primary objective of seasonal wetland management is to provide an abundance and diversity of seeds, aquatic invertebrates, and other foods for wintering waterfowl and other wildlife. The wetlands also are managed to control the extent of tules and cattails; and more recently, water hyacinth. A portion of the managed wetlands occur within rice fields which are flooded in the winter to provide waterfowl habitat for feeding and resting habitats. A variety of annual plants germinate on the exposed mudflats of seasonal wetlands during the spring draw down, including swamp timothy, watergrass, smartweed, and cocklebur. These plants are then managed through the timing, duration or absence of summer irrigation. The mudflats support sandpiper, plover, avocet, stilt, and other shorebirds.

Managed semi-permanent wetlands, commonly referred to as “brood ponds,” are flooded during the spring and summer, but may experience a 2 to 6 month dry period each year. These semi-permanent wetlands provide breeding ducks, ducklings, and other wetland wildlife with protection from predators and abundant invertebrate food supplies (DFG and Yolo Basin Foundation 2008). Permanent wetlands remain flooded throughout the year. Due to year-round flooding, permanent wetlands support a diverse, but usually not abundant, population of invertebrates. Permanent managed wetlands provide deep water habitat for diving ducks, such as Ruddy Duck, Scaup, and Goldeneye; and other water birds, including Pied-Billed Grebe, coot, and moorhen. They often have dense emergent cover on their edges that is the preferred breeding habitat for Marsh Wren and Red-Winged Blackbird; and roosting habitat for Black-Crowned Night Heron, White-Faced Ibis, and egret.

The managed wetlands are operated by private hunting clubs; private conservation entities, including conservation banks; and the Federal and state governments (CALFED et al. 2001). Some of the hunting clubs have implemented wetland management agreements with CDFW under the State Presley Program or Wetland Easement Program to coordinate the timing and patterns of flooding, drawdowns, irrigation, soil disturbance, and maintenance of brood habitat. The patterns may be adjusted annually to respond to specific wildlife and hydrologic needs. A similar program focused on providing spring habitat for breeding is provided by the Federal Waterbank Program.

Habitat in the Yolo Bypass is affected by periodic flooding (CALFED et al. 2001). Following a flood, roads, canals, and ditches may need to be excavated; debris needs to be removed from habitat, and water delivery facilities may need to be repaired. Flooding also disrupts nesting and resting activities of birds. During floods, hunting activities are diminished or ceased.

10.3.3.4.3 Agricultural Lands in the Delta, Suisun Marsh, and Yolo Bypass

Major crops and cover types in agricultural production in the Delta and Suisun Marsh include small grains (wheat and barley), field crops (corn, sorghum, and safflower), truck crops (tomato and sugar beet), forage crops (hay and alfalfa), pastures, orchards, and vineyards. The distribution of seasonal crops varies annually, depending on crop rotation patterns and market forces. In many areas, cropping practices result in monotypic stands of vegetation for the growing season and bare ground in fall and winter. Some farmland is more intensively managed to provide wildlife habitat in addition to crops. Regular maintenance of fallow fields, roads, ditches, and levee slopes can reduce the establishment of ruderal vegetation or native plant communities.

Agriculture has been present in the Yolo Bypass since the seasonal wetlands and perennial marsh and riparian areas were first converted to farms in the mid-1800s. For many years, grazing was the primary use of agricultural lands in the Yolo Bypass. In the latter part of the 20th century, irrigation systems were developed and fields were engineered for the production of row crops (DFG and Yolo Basin Foundation 2008). Periodic flooding of the bypass limits the types of crops that can be grown. The Yolo Bypass Wildlife Area utilizes agriculture to manage habitats while providing income for the management and operation of the property. Working with local farmers, the Yolo Bypass Wildlife Area provides fields of milo, corn, and Sudan grass specifically for wildlife forage. Rice is grown, harvested, and flooded to provide food for thousands of waterfowl. Corn fields are harvested to provide forage for geese and cranes. Crops such as safflower are cultivated and mowed to provide seed for upland species such as Ring-Necked Pheasant and Mourning Dove. Row and truck crops are grown across the northern half of the Yolo Bypass Wildlife Area. The primary crops grown include rice, corn, millet, milo, safflower, sunflower, and tomatoes. These crops are cultivated during the summer months. From fall to spring, some farmed areas are fallowed and flooded to provide forage for wildlife as well as seasonal wetland habitat. An extensive area at the southern end of the wildlife area is used for grazing cattle. Cattle are brought onto the Yolo Bypass Wildlife Area in mid-spring or early summer after the threat of flooding has passed and are removed by January. Forage is provided in irrigated pasture, uplands within the bypass and the annual grassland-vernal pool complex. Alfalfa is only grown in the western portion of the bypass south of Interstate 80, along with a variety of row crops that are grown in this region (Yolo County 2013).

10.3.3.4.4 Wildlife Refuges in the Delta, Suisun Marsh, and Yolo Bypass

A number of wildlife areas that could be affected by changes in long-term operations of CVP and SWP are located in the Delta, Suisun Marsh, and Yolo Bypass. Conditions in the Yolo Bypass, including the Yolo Bypass Wildlife Area, are described above and not repeated in this subsection.

Stone Lakes National Wildlife Refuge

The Stone Lakes NWR is located in the Beach-Stone Lakes Basin about 10 miles south of the city of Sacramento. It was established in 1994 and the refuge area is approximately 18,000 acres, of which about 9,000 acres is in a core refuge area owned by the USFWS and an approximately 9,000-acres “Cooperative Wildlife Management Area” where the USFWS seeks to enter into cooperative agreements or purchase conservation easements from willing landowners. The USFWS actively manages around 6,000 acres on the refuge (USFWS 2007).

The refuge vegetative communities include agricultural lands, open water, perennial freshwater wetlands, cottonwood-willow riparian, irrigated pasture and wet meadow, managed permanent and seasonal wetland, orchards, riparian scrub, upland forest, valley oak riparian woodland, vernal pool, and grasslands that facilitate wildlife movement and help compensate for habitat fragmentation and buffers the effects of urbanization on agricultural lands in the Delta region (USFWS 2007).

The diverse vegetation provides habitat for a wide ranges of mammals, birds, reptiles, and amphibians similar to those described for other sections of the Sacramento Valley (USFWS 2007). The grasslands, pastures, woodlands support White-Faced Ibis, Geese, Black-Bellied Plover, Great Blue Heron, Great Egret, Greater Sand Hill Crane, Northern Harrier, White-Tailed Kite, Red-Shouldered Hawk, Swainson’s Hawk, Great Horned Owl, Barn Owl, Bald Eagle, Golden Eagle, American Kestrel, Prairie Falcon, Tree Swallow, Barn Swallow, Cliff Swallow, songbirds, and birds that use the grasslands, including killdeer, Ring-Necked Pheasant, Burrowing Owl, Mourning Dove, Brewer’s Blackbird, and Turkey Vulture. The waterfowl species include Tundra Swan, White-Fronted Goose, Snow Goose, Canada Goose, Mallard, Northern Pintail, Northern Shoveler, Cinnamon Teal, Green-Winged Teal, Wood, and Ruddy ducks. The wetland areas also support Common Yellowthroat, Red-Winged Blackbird, Marsh Wren, coot, Cormorant, and American White Pelican. Other wildlife species on this refuge include coyote, Deer Mouse, Pocket Gopher, Black Tailed Hare, California Vole, California Ground Squirrel, Pacific Tree Frog, bullfrog, pond turtle, Pond Slider Turtle, Western Fence Lizard, Western Terrestrial Garter Snake, Gopher Snake, Common Garter Snake, California King Snake, and Western Toad.

The riparian cottonwood forests include Fremont cottonwood, Gooding’s willow, California grape, California boxelder, California blackberry, white-stemmed raspberry, buttonbush, and blue elderberry. The mixed riparian forest includes valley oak with vegetation similar to the riparian cottonwood forest but at lower densities. The valley oak riparian forest is dominated by valley oak, Oregon ash, California sycamore, and California black walnut with an understory of grasses, vines, and shrubs, including California blackberry and wild rose. The perennial wetlands include cattails, tules, cottonwood, willows, sedges, and rushes with areas of watergrass, smartweed, and swamp timothy that also occur in seasonal wetlands. The riparian vegetation provides vast amounts of insects, perches, and cover to support the wide range of bird species, the valley oak woodlands provide acorns, insects, and perch and nesting sites. The wetland sites provide foraging opportunities for waterbirds and upland species.

Miner Slough Wildlife Area

The Miner Slough Wildlife Area within the Delta is about 10 miles north of Rio Vista at the junction of Miner and Cache sloughs and is accessed by boat (CDFW 2014d). The 37-acre Wildlife Area includes approximately 10 acres of tidal wetlands which become a narrow peninsula extending from Prospect Island at low tide. The riparian vegetation of willow, cottonwood, tules, and blackberry support a wide range of wildlife species including beaver, black-crowned night heron, and waterfowl.

Decker Island Wildlife Area

Decker Island is a 648-acre island located about 20 feet above sea level surrounded by the Sacramento River and Horseshoe Bend in the Delta just south of Rio Vista (DWR 2003; Philipp 2005). The island was created between 1917 and 1937 as part of the actions to implement the Sacramento Deep Water Ship Channel, as described in Chapter 5, Surface Water Resources and Water Supplies. CDFW owns the northernmost 33 acres of Decker Island and has been working with the California Department of Water Resources (DWR) to reestablish and enhance wetland and upland habitats. The vegetation includes shallow water channels lined with thick stands of tules, sedges, willow, and alder. Many mammal species have been observed, including river otter, mink, beaver, coyote, mice, and voles. Various species of raptors, waterfowl, songbirds, and shorebirds have also been observed. Amphibians and reptiles such as Pacific Tree Frog, Western Fence Lizard, and Gopher Snake have been seen. Invasive plants such as perennial pepperweed, yellow star thistle, water hyacinth, Brazilian water weed and Egeria continue to pose a threat to restoration efforts.

Lower Sherman Island Wildlife Area

The Lower Sherman Island Wildlife Area occupies roughly 3,100 acres, primarily marsh and open water, at the confluence of the Sacramento and San Joaquin Rivers in the western Delta (DFG 2007). Riparian vegetation is characterized by narrow linear strips of trees and shrubs, in single-to multiple story canopies. Riparian vegetation primarily occurs along the historic levees above elevations that support tidal marsh. Native woody plant species occurring in the riparian strip include Fremont cottonwood, willow, red alder, and California wild rose. The invasive nonnative, Himalayan blackberry infests many of these areas. Marsh vegetation includes both emergent marsh and areas of floating aquatic vegetation. Most emergent marsh is dominated by bulrush, cattail, and common reed. In the northwestern portion of Lower Sherman Island, there is also upper elevation marsh dominated by pickleweed and saltgrass. Grasslands are dominated by annual grasses, but also include many perennial species that are also typical in seasonal wetlands. Pampas grass and perennial pepperweed, two invasive nonnative species are also found in the grassland areas.

At the Lower Sherman Island Wildlife Area, habitat exists for a wide variety of wildlife species, including numerous bird species, mammals, reptiles, and amphibians (DFG 2007). Many of the bird species that occur in the wildlife area are migratory and are there only, or primarily, during the fall and winter months. Wintering birds include waterfowl, shorebirds, wading birds, and raptors. Other groups that utilize the wildlife area seasonally include upland game species, cavity-nesting birds, and neotropical migratory birds. Typical mammal species found in the upland grassland and disturbed areas of the wildlife area include Striped Skunk, raccoon, squirrel, voles, Pocket Gopher, feral cats, fox, and coyote. Muskrat and beaver may be found in the marsh vegetation. Typical reptiles and amphibians include Western Fence Lizard, snake, frog, and toad.

Rhode Island Wildlife Area

Rhode Island Wildlife Area is a 67-acre island, located in Contra Costa County that is managed by CDFW (CDFW 2014e). The vegetation along the perimeter of the island includes alder, willow, blackberry, and tule. The interior open water areas include marsh vegetation of tule and cattail. The island provides habitat for river otters, beaver, muskrat, and many species of birds including Great Blue Heron; Black-Crowned Night Heron; egrets; and Mallard, Cinnamon Teal, and Wood ducks.

White Slough Wildlife Area

The White Slough Wildlife Area, west of Lodi and north of Stockton, is an 880-acre area refuge with open water, freshwater marsh, grassland/upland area, and riparian habitats (CDFW 2014f). The area supports upland game birds such as Ring-Necked Pheasant, California Quail, Mourning Dove, and a range of waterfowl species similar to those described for the Delta and Yolo Bypass.

Hill Slough Wildlife Area

Hill Slough Wildlife Area, located in the northern part of Suisun Marsh, is operated by CDFW and contains 1,723 acres of saltwater tidal marsh, managed marshes, slough, and upland grassland (CDFW 2014g). The area supports a wide variety of waterfowl, including Northern Pintail, Mallard, Northern Shoveler, and Green-Winged Teal ducks; and American wigeon. Ferruginous Hawks and Rough-Legged Hawks winter in the area while year-round residents such as Golden Eagle, Northern Harrier, and Red-Tailed Hawk which forage over the ponds and upland areas. Mammals including raccoon, jackrabbit, and voles are found here and are preyed upon by the coyotes that hunt and live in the wildlife area.

Grizzly Island Wildlife Area

Grizzly Island Wildlife Area is administered by CDFW and consists approximately 15,300 acres of tidal wetlands and managed marshes within Suisun Marsh (CDFW 2014h, 2014i). The CDFW manages waterways to create more than 8,500 acres of seasonal ponds containing alkali bulrush and fat-hen. Grizzly Island Wildlife Area includes habitats that support Northern Pintail Duck, Green-Winged Teal Duck, American Widgeon, Tule Goose, egret, Great Blue Heron, Snowy Egret, Black-Crowned Night Heron, Yellowthroat, Marsh Wren, Suisun Song Sparrow, American White Pelican, Ferruginous Hawk, Sharp-Shinned Hawk, white Tailed Kite, Red-Tailed Hawk, Prairie Falcon, Peregrine Falcon, Northern Harrier, and Short-Eared Owl. The Grizzly Island Wildlife Area also supports mammals, including Plush River Otter and Tule Elk.

Point Edith Wildlife Area

Point Edith Wildlife Area is located in Contra Costa County, approximately 2.5 miles east of Martinez. The Point Edith Wildlife Area includes approximately 760 acres of marshes which is accessed by boat. The habitat includes open water and tidal wetlands that support waterfowl, including coot and moorhen (CDFW 2014j).

Fremont Weir Wildlife Area

The Fremont Weir Wildlife Area is located within the Yolo Bypass from the Sacramento River to downstream of the Fremont Weir. During high flows, water from the Sacramento River flows into the Yolo Bypass over the Fremont Weir as part of the Sacramento River Flood Control Project, as described in Chapter 5, Surface Water Resources and Water Supplies. The 1,461-acre refuge includes valley oak, willow, cottonwood, brush, and weedy vegetation (CDFW 2014k). The area supports pheasant, Valley Quail, Mourning Dove, a range of waterfowl species similar to those described for the Yolo Bypass, Cottontail Rabbit, and jackrabbit.

Sacramento Bypass Wildlife Area

The Sacramento Bypass Wildlife Area is located along a channel that connects the Sacramento River to the Yolo Bypass. During high flows, water from the Sacramento River flows into the Yolo Bypass through the Sacramento Bypass as part of the Sacramento River Flood Control Project, as described in Chapter 5, Surface Water Resources and Water Supplies. The 360-acre refuge includes valley oak, willow, cottonwood, and weedy vegetation (CDFW 2014l). The area supports raptors, songbirds, pheasant, Mourning Dove, and a range of mammal species similar to those described for the Yolo Bypass.

Calhoun Cut Ecological Reserve

The Calhoun Cut Ecological Reserve is located within the Cache Slough area and is only accessed by boat through Lindsay Slough (CDFW 2014m). Vegetation in Calhoun Cut includes grasslands, marshes, and riparian vegetation (Witham and Karacfelas 1994). The grasslands include native purple needlegrass grasslands and vernal pools.

10.3.4 San Francisco Bay Area Region

The San Francisco Bay Area Region includes portions of Contra Costa, Alameda, Santa Clara, San Benito, and Napa counties that are within the CVP and SWP service areas. The CVP and SWP water supplies are used in the San Francisco Bay Region by Contra Costa Water District, East Bay Municipal Utility District, Zone 7 Water Agency, Alameda County Water District, Santa Clara Valley Water District, San Benito County Flood Control and Water Conservation District, and Napa County Flood Control and Water Conservation District. The majority of the CVP and SWP water uses in the San Francisco Bay Area Region are for municipal and industrial land uses. Agricultural areas that use CVP and SWP water are located within coastal valleys, especially within the Livermore-Amador valleys of Alameda County, southern Santa Clara County, and northern San Benito County.

Many of these agencies store the CVP and/or SWP water supplies in surface water reservoirs, including CVP Contra Loma and San Justo reservoirs; the SWP Bethany Reservoir and Lake Del Valle; the Contra Costa Water District Los Vaqueros Reservoir; and the East Bay Municipal Utility District Upper San Leandro, San Pablo, Briones, and Lafayette reservoirs and Lake Chabot. CVP and SWP are generally not stored in reservoirs within Santa Clara County (SCVWD 2010). Operation of the reservoirs is dependent upon the volume of CVP and/or SWP water blended with other water supplies used by these agencies. Surface water streams are not used to convey the water from the CVP and/or SWP facilities to the reservoirs. As described in subsection 10.3.2, Overview of Species with Special Status, A listing of wildlife and plant species with special status that occur or may occur in portions of the study area affected by the long-term coordinated operation of the CVP and SWP is provided in Appendix 10A.

The USFWS has approved two habitat conservation plans in the areas served by CVP and SWP water supplies, including the East Contra Costa County Habitat Conservation Plan/Natural Community Conservation Plan and the Santa Clara Valley Habitat Plan (ECCCHCPA 2006; Reclamation et al. 2009; Santa Clara County et al. 2012).

10.3.4.1 Central Valley Project Reservoirs

The CVP reservoirs in the San Francisco Bay Area Region include Contra Loma and San Justo reservoirs.

10.3.4.1.1 Contra Loma Reservoir

The Contra Loma Reservoir is a CVP facility in Contra Costa County that provides offstream storage along the Contra Costa Canal, as described in Chapter 5, Surface Water Resources and Water Supplies. The 80-acre reservoir is part of 661-acre Contra Loma Regional Park and Antioch Community Park (Reclamation 2014a). The Contra Loma Reservoir area includes open space and recreation facilities. In the open space, vegetative communities include grasslands, blue oak woodland, valley foothill riparian, fresh emergent wetlands, riverine, and open water communities. The annual grasslands include smooth brome, slender wild oats, Italian ryegrass, yellow star thistle, white-stem filaree, and mouse-ear chickweed. Valley foothill riparian occurs along intermittent streams and includes valley oaks, cottonwoods, red willows, Himalayan blackberry, poison oak, and mulefat. The riverine and fresh emergent wetland communities include ryegrass, curly dock, hyssop, loosestrife, Baltic rush, flowering quillwort, cattails, rushes, dallis grass, nutsedge, and cocklebur. Watermilfoil occurs along portions of the shoreline. Recreation areas include urban trees with Oregon ash, black walnut, Fremont cottonwood, blue oak, valley oak, interior live oak, fig, and eucalyptus. East Bay Regional Parks District has initiated restoration actions to improve native grasslands and riparian and provide habitat for quail.

Wildlife in the grasslands areas include Burrowing Owl, Horned Lark, Western Meadowlark, Turkey Vulture, Northern Harrier, American Kestrel, White-Tailed Kite, Red-Tailed Hawk, Brewer’s Blackbird, Mourning Dove, Western Fence Lizard, Common Garter Snake, Western Rattlesnake, Black-Tailed Jackrabbit, California Ground Squirrel, Botta’s Pocket Gopher, Western Harvest Mouse, California Vole, American Badger, Mule Deer, and coyote (Reclamation 2014a). The valley foothill riparian and blue oak woodland vegetation support a wide range of birds including Northern Flicker, Yellow Warbler, Acorn Woodpeckers, Western Scrub Jay, White-Tailed kite, Cooper’s Hawk, Red-Shouldered Hawk, American Kestrel, Great Horned Owl, Song Sparrow, Black Phoebe, European Starling, Western Bluebird, and Tree Swallow. The valley foothill riparian and blue oak woodland vegetation also support Pacific Tree Frog, Red-legged Frog, Sharp-Tailed Snake, California Alligator Lizard, Common Garter Snake, Mule Deer, Raccoon, Coyote, Striped Skunk, Deer Mouse, Harvest Mouse, Dusky-Footed Woodrat, and Gray Fox. Riverine and wetlands, and open water support Brewer’s Blackbird, Red-Winged Blackbird, Brown-Headed Cowbird, Great Blue Heron, Great Egret, ducks, American Coot, Common Merganser, Double-Crested Cormorant, American Wigeon, Canada Goose, Western Grebe, and gull; Pacific Tree Frog, Red-legged Frog, Bullfrog, California Tiger Salamander, Western Pond Turtle, Western Toad, and Garter Snake; Deer Mouse, California Vole, Long-Tailed Weasel, and other mammals that use the adjacent woodlands and grasslands.

10.3.4.1.2 San Justo Reservoir

The San Justo Reservoir is a CVP facility in San Benito County that provides offstream storage as part of the San Felipe Division, as described in Chapter 5, Surface Water Resources and Water Supplies. The reservoir is surrounded by steep hills with recreational facilities on the northeast side reservoir and intermittent streams, wetlands, and open water downslope of the reservoir (SBCWD 2012). Adjacent land uses are dominated by irrigated row crops, orchards, and rangeland. Vegetation and wildlife resources of the reservoir area are consistent with grasslands vegetation on uplands.

10.3.4.2 State Water Project Reservoirs

Bethany Reservoir, Patterson Reservoir, and Lake Del Valle are SWP facilities associated with the South Bay Aqueduct in Alameda County, as described in Chapter 5, Surface Water Resources and Water Supplies.

Vegetative communities around Bethany Reservoir are characterized by nonnative grasses with several areas of woodland habitat (DWR 2014). The grassland habitat includes slender oat, ripgut brome, soft chess, wild barley, Italian ryegrass, black mustard, bull thistle, redstem filaree, dissected geranium, English plantain, and tumble mustard; and forbs, including sweet fennel, Great Valley gumweed, Mediterranean linseed, and Ithuriel’s spear. The woodland habitat includes white ironbark, Casuarina, and Bishop pine. Coyote bush occurs along the water edge. The grasslands provide habitat for Mourning Dove, Western Scrub-Jay, Finches, Sparrows, Owls, Hawks, California Ground Squirrel, Black-Tailed Jackrabbit, Audubon's Cottontail, Botta's Pocket Gopher, California vole, mice, frogs, toads, salamanders, snakes, lizards, and turtles. The woodlands support Red-Tailed Hawk, Osprey, Owls, Black Phoebe, Bullock's Oriole, Yellow Warbler, amphibians and reptiles, and coyote. Emergent vegetation does not occur along the shoreline at Bethany Reservoir (DWR 2005).

Patterson Reservoir is a small, 100-acre-foot, SWP reservoir located along the South Bay Aqueduct between Bethany Reservoir and Lake Del Valle. Vegetation around Patterson Reservoir is characterized by grasslands and upland habitat. Red-legged Frog has been observed in the vicinity of Patterson Reservoir (DWR 2014).

Lake Del Valle is a 77,100 acre-foot SWP facility located along the South Bay Aqueduct (DWR 2001). Vegetation around Lake Del Valle includes grasslands, chaparral, shrub, oak woodland, and riparian and freshwater habitats (EBRPD 1996, 2001, 2012, 2013). The grasslands include nonnative grasses and native perennial bunchgrass. The nonnative grasslands include grasses such as wild oats, bromes, ryegrass, wild barley, silver hairgrass, and dogtail grass; forbs, including filaree, clover, and plantain; and lupine, yarrow, and soap plant. Native grasses include annual and perennial fescues, needlegrass, wild ryes, junegrass, and California bromegrass. The coastal scrub and chaparral vegetation includes coyote brush-scrub, California sagebrush, manzanita, black sage, cream bush, California coffeeberry, yerba santa, blackberry, bush monkeyflower, and poison oak. The oak woodlands and riparian woodlands include coast live oak, black oak, valley oak, scrub oak, California bay, and California buckeye. Mixed deciduous riparian woodlands occur along perennial streams, including white alder, big-leaf maple, western sycamore, willow, and Fremont cottonwood. Along springs and seeps, the vegetation includes rabbitsfoot grass, saltgrass, bentgrasses, rushes, tules, sedges, horsetails, and cattail, buttercup, brass-button, mint, duckweed, pondweed, and ferns.

10.3.4.3 Contra Costa Water District Los Vaqueros Reservoir

Los Vaqueros Reservoir is a Contra Costa Water District offstream storage facility in Contra Costa County, as described in Chapter 5, Surface Water Resources and Water Supplies. The area around the Los Vaqueros reservoir includes grasslands, upland scrub, valley and foothill woodlands, freshwater wetlands, and open water habitats (Reclamation et al. 2009). The grasslands include perennial and alkali habitats with wild oats, ripgut brome, yellow star thistle, fescue, filaree, mustard, fiddleneck, lupine, popcorn flower, and California poppy. The grasslands support Northern Harrier, Burrowing Owl, Western Meadowlark, California Horned Lark, Turkey Vulture, Red-Tailed Hawk, American Kestrel, White-Tailed Kite, Western Fence Lizard, Common Garter Snake, Western Rattlesnake, California Tiger Salamander, Western Harvest Mouse, California Ground Squirrel, Black-Tailed Jackrabbit, Black-Tailed Deer, and San Joaquin Kit Fox.

The upland scrub habitat is dominated by evergreen chaparral species and coastal scrub, including chamise, California sagebrush, black sage, poison oak, bush monkeyflower, and California buckwheat underlain by annual grasses and purple needlegrass (Reclamation et al. 2009). This habitat supports California Quail, Western Scrub-Jay, Bushtit, California Thrasher, Spotted Towhee, Sage Sparrow, Western Fence Lizard, Common Garter Snake, Common King Snake, Western Rattlesnake, California Mouse, Deer Mouse, and feral pig.

The valley and foothill woodlands and riparian woodlands includes willow, Fremont cottonwood, valley oak, sycamore, black walnut, California buckeye, Mexican elderberry, and Himalayan blackberry which occur along much of Kellogg Creek (Reclamation et al. 2009). This habitat supports many birds, reptiles, amphibians, and mammals, including red-legged frog. The freshwater emergent habitat includes meadows with wetland species and stream channels. The vegetation includes tules, bulrushes, and cattail. Wildlife that occurs in this area include Marsh Wren, Common Yellowthroat, Red-Winged Blackbird, Red-legged Frog, and Western Pond Turtle. The open water habitat of the Los Vaqueros Reservoir provides forage, winter, and brood habitat for Canada Goose; American Wigeon; Wood,, Gadwall, Mallard, Northern Shoveler, Northern Pintail, Green-Winged Teal, Canvasback, Redhead, Ring-Necked, Greater Scaup, Lesser Scaup, Bufflehead, Common Goldeneye, Hooded Merganser, Common Merganser, and Ruddy ducks; and other habitat values for grebe, sandpiper, pelican, cormorant, egret, heron, and gull.

10.3.4.4 East Bay Municipal Utility District Reservoirs

The East Bay Municipal Utility District reservoirs in Alameda and Contra Costa County used to store water within and near the East Bay Municipal Utility District service area include Briones Reservoir, San Pablo Reservoir, Lafayette Reservoir, Upper San Leandro Reservoir, and Lake Chabot. Water stored in these reservoirs includes water from local watersheds, the Mokelumne River watershed, and CVP water supplies, as described in Chapter 5, Surface Water Resources and Water Supplies.

The Briones Reservoir watershed is characterized by grasslands, chaparral, coastal scrub, oak and bay woodlands, riparian, and freshwater wetlands (EBMUD 1999; EBRPD 1996, 2001, 2013). The San Pablo Reservoir watershed is characterized by grasslands, hardwood forest, coastal scrub, Monterey pine planted along the reservoir shoreline, riparian woodland, and eucalyptus. The Lafayette Reservoir watershed is characterized by grasslands, oak and bay woodland, and coastal scrub. The Upper San Leandro Reservoir watershed includes grasslands, chamise-black sage chaparral, coastal scrub, oak and bay woodland, redwood forest, knobcone forest with a dense manzanita understory, and an 18-acre freshwater marsh. The Lake Chabot watershed includes grasslands, coastal scrub, oak and bay woodland, and riparian and freshwater vegetation.

The grasslands vegetative communities generally include nonnative grasses and native perennial bunchgrass (EBMUD 1999; EBRPD 1996, 2001). The nonnative grasslands include grasses such as wild oat, bromegrass, ryegrass, wild barley, bluegrass, silver hairgrass, and dogtail grass; forbs, including filaree, bur clover, clovers, owls clover, cat's ear, and English plantain; and brodiaeas, lupine, mariposa lilies, mule's ear, yarrow, farewell to spring, and soap plant. Native grasses include annual and perennial fescues, needlegrass, wild rye, California oatgrass, junegrass, bluegrass, squirreltail, meadow barley, and California bromegrass. Grasslands are used by wildlife similar to those described for other San Francisco Bay Area reservoirs, including hawks, owls, shrikes, swallows, turkey vulture, reptiles, coyote, fox, bobcat, and mice.

The coastal scrub and chaparral vegetation includes coyote brush-scrub, California sagebrush, bitter cherry scrub, manzanita, chamise-black sage, cream bush, California coffeeberry, wild lilac, yerba santa, blackberry, bush monkeyflower, and poison oak (EBMUD 1999; EBRPD 1996, 2001). The woodlands include native and nonnative plants. The native redwood and knobcone pine forests are located at Upper San Leandro Reservoir and provide unique habitat. Nonnative eucalyptus and Monterey pine forests occur at San Pablo Reservoir and Lake Chabot. The eucalyptus trees provide specific habitat for hummingbird, Bald Eagle, Great Blue Heron, and Great Egret. The oak and bay woodlands and oak savannas include coast live oak, black oak, valley oak, blue oak, interior live oak, canyon live oak, California bay, California buckeye, and madrone.

Mixed deciduous riparian woodland occur along perennial streams, including white alder, big-leaf maple, western sycamore, Fremont cottonwood, and black cottonwood that supports frogs, newts, and other amphibians; coast live oak, California bay, and willow woodlands on steep slopes along intermittent streams; and willow riparian scrub along perennial and intermittent streams (EBMUD 1999; EBRPD 1996, 2001). Along springs and seeps, the vegetation includes grasses, includes rabbitsfoot grass, saltgrass, bentgrasses, rushes, tules, sedges, horsetails, and cattail; and forbs includes buttercup, watercress, stinging nettle, brass-buttons, mints, duckweed, and pondweed.

10.3.5 Central Coast Region

The Central Coast Region includes portions of San Luis Obispo and Santa Barbara counties served by the SWP. The SWP water is provided to the Central Coast Region by the Central Coast Water Authority (CCWA 2013). The facilities divert water from the SWP California Aqueduct at Devil's Den and convey the water to a 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. Water is delivered to southern Santa Barbara County communities through Cachuma Lake.

As described in subsection 10.3.2, Overview of Species with Special Status, A listing of wildlife and plant species with special status that occur or may occur in portions of the study area affected by the long-term coordinated operation of the CVP and SWP is provided in Appendix 10A.

10.3.5.1 Cachuma Lake

Cachuma Lake is a facility owned and operated by Reclamation in Santa Barbara County, as described in Chapter 5, Surface Water Resources and Water Supplies. The Cachuma Lake watershed is located in the Coast Range and extends into the Los Padres National Forest. The primary habitats include hardwood woodland, chaparral, coastal sage scrub, nonnative grassland, and riparian woodland and scrub (Reclamation 2010c). The hardwood woodlands includes oak woodland, oak savannah, and pine woodland with blue oak, coast live oak, gray pine, skunk brush, and poison oak. The chaparral and coastal sage scrub includes mountain mahogany, greenbark ceonothus, blue oak, interior live oak, scrub oak, holly leaf redberry, buck brush, toyon, chaparral mallow, chamise, California sage brush, purple sage, deer weed, and coyote brush-scrub with understory of grasses and forbs. Birds that use the hardwood woodlands and savannah include Turkey Vulture; raptors including Red-Tailed Hawk and Bald Eagle; woodpecker, California Quail, Rufous-Crowned Sparrow, wrentit, California Thrasher, and Spotted Towhee. Nonnative grasslands are dominated by rip-gut brome and dove weed. Native grasses include purple needlegrass, blue-eyed grass, Johnny-jump-up, Chinese houses, rusty popcorn flower, slender cottonseed, forget-me-not, lupine, mountain dandelion, checkerbloom, narrow-leaved milkweed, fleabane, vinegar weed, California milkweed, and verbena.

Riparian habitat along streams and stream terraces include arroyo willow, red willow, yellow willow, black willow, sycamore, oak, cottonwood, Pacific blackberry, California rose, poison oak, elderberry, mulefat, California goldenrod, California brome, black mustard, mugwort, clover, stinging nettle, red brome, and California buckwheat (Reclamation 2010c). Habitat near the shoreline of Cachuma Lake includes willows, tamarisk, cattail, mulefat, and mugwort. Disturbed lands around the lake are characterized by weedy species, including yellow star thistle, Spanish broom, tamarisk, giant reed, pampas grass, scotch broom, veldt grass, perennial pepperweed, red brome, fennel, and cheatgrass. Marginal vegetation, reedy marshes, and riparian woodland support killdeer, spotted Sandpiper, Red-Winged Blackbird, Common Yellowthroat, Song Sparrow, Marsh Wren, Warbling Vireo, Yellow Warbler, Yellow-Breasted Chat, and Brown-Headed Cowbird. The open water of Cachuma Lake supports diving birds, including diving duck, American Coot, Pied-Billed Grebe, Western Grebe, Clark’s Grebe, Double-Crested Cormorant, Heron, Egret, pelican, Osprey, and Bald Eagle. Amphibians and reptiles that occur near Cachuma Lake include Monterey Salamander, California Slender Salamander, Western Spadefoot, California Toad, Pacific Tree Frog, Bullfrog, Red-legged Frog, Yellow-Legged Frog, Southwestern Pond Turtle, Western Skink, and Southern Alligator Lizard. Mammals which depend upon habitat near Cachuma Lake include bat, hare, rabbit, pika, bear, coyote, fox, weasel, raccoon, cats, chipmunk, squirrel, marmot, shrew, mice, rat, mule deer, and feral pig.

10.3.6 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 SWP water supplies generally are conveyed to Southern California municipal, industrial, and agricultural water users in canals and pipelines. There are six SWP reservoirs along the main canal, West Branch, and East Branch of the California Aqueduct and many other reservoirs owned and operated by regional and local agencies. The Metropolitan Water District of Southern California's Diamond Valley Lake and Lake Skinner primarily store water from the SWP. Other reservoirs store SWP water, including United Water Conservation District's Lake Piru; City of Escondido's Dixon Lake; City of San Diego's San Vicente Reservoir and Lower Otay Reservoir; Helix Water District's Lake Jennings; and Sweetwater Authority's Sweetwater Reservoir.

As described in subsection 10.3.2, Overview of Species with Special Status, A listing of wildlife and plant species with special status that occur or may occur in portions of the study area affected by the long-term coordinated operation of the CVP and SWP is provided in Appendix 10A.

The USFWS has approved several habitat conservation plans in the Southern California Region within areas served by CVP and SWP water, including the following plans (County of Orange 1996; Riverside County 2003; Riverside County Habitat Conservation Agency 2014; SDCWA and USFWS 2010; San Diego County 2014a, 2014b, 2015; SANDAG 2003; CVAG 2007).

- County of Orange Central and Coastal Subregion Natural Community Conservation Plan and Habitat Conservation Plan.
- Western Riverside County Multiple Species Conservation Plan.
- Habitat Conservation Plan for the Stephen's Kangaroo Rat in Western Riverside County which is administered by the Riverside County Habitat Conservation Agency for Riverside County and the cities of Corona, Hemet, Lake Elsinore, Menifee, Moreno Valley, Murrieta, Perris, Riverside, Temecula, and Vail Lake, and which includes areas around Diamond Valley Lake and Lake Skinner.
- San Diego County Water Authority Subregional Natural Community Conservation Plan/Habitat Conservation Plan (NCCP/HCP).
- San Diego County Multiple Species Conservation Plan including the initial area which includes the lands served by the City of San Diego Wastewater Sewer System; future North County Plan expansion (extends from the areas near the cities of Oceanside, Encinitas, San Marcos, Vista, and Escondido to the Cleveland National Forest and Riverside County boundary), and remaining land within the county (including lands from Alpine east to the Imperial and Riverside counties boundaries).
- Multiple Habitat Conservation Program for the cities of Carlsbad, Encinitas, Escondido, Oceanside, San Marcos, Solana Beach, and Vista.
- Coachella Valley Multiple Species Habitat Conservation Plan.

10.3.6.1 State Water Project Reservoirs

The SWP reservoirs include Quail Lake, Pyramid Lake, and Castaic Lake in Los Angeles County; Silverwood Lake and Crafton Hills Reservoir in San Bernardino County; and Lake Perris in Riverside County, as described in Chapter 5, Surface Water Resources and Water Supplies.

Quail Lake was formed by seismic activity on the San Andres Fault and enlarged by the Department of Water Resources (DWR) as part of the West Branch of the SWP (DWR 1997). Quail Lake is bordered by the Tehachapi and Liebre Mountains. The area is characterized by cottonwood and oak woodlands that support Crested Sparrow, Red-Winged Blackbird, Golden Eagle, Red-Tailed Hawk, fox, coyote, deer, squirrel, and Pronghorn Antelope. The open water habitat support Canada Geese, egrets and Blue Herons

Pyramid Lake is located in the Angeles and Los Padres National Forests, as described in Chapter 15, Recreation Resources. Upland areas around Pyramid Lake are assumed to be similar to upland areas around Middle Piru Creek downstream of Pyramid Dam (DWR 2004c). The vegetative communities include coastal sage scrub and chaparral with oak woodlands and nonnative grasslands. Water is released from Pyramid Lake to provide habitat flows in Piru Creek, including flows to support habitat for the Arroyo Toad.

Terrestrial resources for Castaic Lake include coastal scrub, red shank-chamise chaparral, and chaparral scrub (DWR 2007b). Castaic Lagoon is located immediately downstream of Castaic Dam and is surrounded by coastal scrub. Vegetation includes pines, eucalyptus, and nonnative and native grasses. The habitat is used by Western Grebe, Canada Goose, Mallard Duck, gull, American Coot, Bald Eagle, and Western Mastiff Bat.

Silverwood Lake is located in the San Bernardino National Forest and surrounded by the Silverwood Lake State Recreation Area at the edge of the Mojave Desert and at the base of the San Bernardino Mountains. The area contains a wide variety of vegetative communities including live oak and scrub oak woodlands, ponderosa pine and Douglas-fir forests, mixed scrub, chaparral, and riparian hardwood (State Parks 2006, 2009). Chamise, interior live oak, manzanita, mountain mahogany, and ceanothus are found along the shoreline and willow, alders, and sycamores grow along area streams. The forest, chaparral, and riparian woodland habitats support a wide variety of small mammals, reptiles, and amphibians including rabbit, squirrel, woodrat, Western Fence Lizard, Rattlesnake, Pacific Tree Frog, California Toad, coyote, Mule Deer, bobcat, beaver, and skunk. The open water supports Great Blue Heron, Western Grebe, Avocet, Egret, Canada Goose, and ducks. A number of raptors are found around the lake including Bald Eagle, Osprey, owls, Cooper’s Hawk, and Red-Tailed hawk.

The Crafton Hills Reservoir area includes 4.5 acres of open water and 1.9 acres of open space (DWR 2009b). The open space is characterized by chaparral scrub and grass species, including chamise, golden yarrow, hoaryleaf ceanothus, brittlebush, California sagebush, California buckwheat, deerweed, black sage, purple needlegrass, heartleaf penstemon, ripgut grass, soft chess, foxtail chess, wild oat, Italian thistle, tocalote, short-pod mustard, and wild oat. The area is used by Mallard Duck, Killdeer, Red-Tailed Hawk, Cassin's Kingbird, and Wrentit; California Toad, Pacific Tree Frog, Western Fence Lizard, Common Side-Blotched Lizard, and California Kingsnake; and Desert Cottontail, Desert Woodrat, coyote, raccoon, and bobcat.

Lake Perris is located adjacent to the cities of Moreno Valley and Perris and the Perris Fairgrounds which includes a motor sports complex (DWR 2010a). Lake Perris is located within the Lake Perris State Recreation Area which provides extensive recreational opportunities, as described in Chapter 15, Recreation Resources. The open space areas are characterized by willow and sage scrub, willow and eucalyptus woodland, and nonnative grassland. The scrub areas include California sagebrush, lemonadeberry, sugarbush, yellow bush penstemon, coyote brush, Mexican elderberry, sweetbush, boxthorn, tall prickly-pear, California buckwheat, red brome, bur ragweed, California aster, ripgut brome, sticky monkeyflower, prickly sow thistle, and Russian thistle. The willow woodland includes Goodding's black willow, red willow, narrow leaved willow, Fremont's cottonwood, California sycamore, gooseberry, mulefat, tarragon, curley dock, ragweed, southwestern spinyrush, and bromes. Eucalyptus woodland includes eucalyptus underlain by nonnative grassland. Nonnative grasslands includes soft chess, wild oat, foxtail barley, mustard, sweet fennel, California sagebrush, and California buckwheat. Habitat has been restored within the grasslands to provide habitat for the Stephen's Kangaroo Rat. Mourning Dove, Anna's Hummingbird, raven, California Kingsnake, Raccoon, Black-Tailed Deer, Striped Skunk, coyote, and bobcat use the shoreline. The woodland is used by Ash-Throated Flycatcher, Western Kingbird, Least Bell's Vireo, House Wren, California Towhee, Spotted Towhee, Black-Headed Grosbeak, Blue Grosbeak, Song Sparrow, Bullock's Oriole, House Finch, Lesser Goldfinch, Nuttal's Woodpecker, Red-Tailed Hawk, Red-Shouldered Hawk, Cooper's Hawk, Cottontail Rabbit, Black-Tailed Jackrabbit, raccoon, and Long-Tailed Weasel. The scrub supports California Quail, Greater Roadrunner, White-Throated Swift, Rock Wren, California Towhee, Western Fence Lizard, Gopher Snake, Red Diamond Rattlesnake, Southern Pacific Rattlesnake, Side Blotched Lizard, Granite Spiny Lizard, Coastal Western Whiptail, Black-Tailed Jackrabbit, bobcat, coyote, and rodents.

10.3.6.2 Non-SWP Reservoirs in Riverside County

Non-SWP reservoirs in Riverside County that store SWP water include Diamond Valley Lake and Lake Skinner that are owned and operated by Metropolitan Water District of Southern California, and Vail Lake that is owned and operated by Rancho California Water District, as described in Chapter 5, Surface Water Resources and Water Supplies.

Diamond Valley Lake is located adjacent to the City of Hemet along the northern boundary, and adjacent to pasture and dairies along the eastern and western boundaries (City of Hemet 2012). Sage scrub and nonnative grasslands occur between the lake and the City of Hemet. Chaparral with sage scrub occur along the southern boundary of the lake. Riversidean sage scrub includes California sagebrush, flat top buckwheat, black sage, and California encelia. Wildlife movement corridors occur around Diamond Valley Lake. Open space around Lake Skinner is also characterized by grassland and sage scrub vegetation (USFWS 2004).

Diamond Valley Lake and Lake Skinner are located within the Southwestern Riverside County Multi-Species Reserve, an area of 11,000 acres surrounding and connecting Diamond Valley Lake and Lake Skinner through the Dr. Roy Shipley Reserve (MWD 2014). At least eight types of habitat are found in the reserve, but coastal sage scrub, nonnative grassland, and chaparral are dominant. There are smaller areas of coast live oak woodland, willow scrub with live oak, and cottonwood-willow riparian forests. The reserve is home to the California Gnatcatcher, Bell's Sage Sparrow, San Diego Horned Lizard, Payson's Jewelflower, and Parry's Spineflower.

Areas around Vail Lake support habitat for Bald Eagle, Golden Eagle, and Great Blue Heron (RCWD 2015).

10.3.6.3 Non-SWP Reservoir in Ventura County

Lake Piru, located in Ventura County, is used to store SWP water by United Water Conservation District, as described in Chapter 5, Surface Water Resources and Water Supplies (UWCD 1999, 2014). The area surrounding the lake is characterized by chaparral on the hills and coast live oak woodlands along the stream channels.

10.3.6.4 Non-SWP Reservoirs in San Diego County

Reservoirs in San Diego County that are used to store SWP water include the City of Escondido Dixon Lake; City of San Diego San Vicente, El Capitan, Lower Otay, and Lake Hodges reservoirs; Lake Jennings owned by Helix Water District; and Sweetwater Reservoir owned by Sweetwater Authority.

Dixon Lake is located in the hills above the City of Escondido within the Escondido Multiple Habitat Conservation Plan area (City of Escondido 2012). Habitat around Lake Dixon is characterized by coastal sage scrub and chaparral. The coastal sage scrub includes California sagebrush, flat-top buckwheat, white sage, laurel sumac, black sage, California encelia, San Diego County viguiera, goldenbush, coast prickly-pear, and lemonadeberry and sugarbush. Chaparral includes chamise, scrub oak, toyon, thick-leaf ceanothus, black sage, wild cucumber, morning glory, saw-toothed goldenbush, and nonnative grasses.

The San Vicente Reservoir is characterized by rocky or coarse sand, with occasional willow trees and mulefat (SDCWA and USACE 2008). The constantly fluctuating water levels make it difficult for wetland or riparian vegetation to become established. Much of the shoreline around San Vicente Reservoir, therefore, is a non-vegetated fringe. Outside of the fringe, the area around the reservoir is primarily sage scrub with nonnative grassland and coast live oak woodland. Along the stream channel, vegetation includes southern willow scrub and live oak riparian forest with chaparral. Submerged aquatic vegetation occurs in an intermittent band surrounding almost the entire reservoir. Freshwater marsh vegetation of cattail, bulrush, and sedges occurs between the open water and lakeshore fringe. Birds associated with the open water include grebe, cormorant, heron, egret, ducks and geese, coot, plover, sandpiper, gull, and tern. Other birds associated with open water and riparian habitats include the bald eagle, osprey, and kingfisher. The uplands support rabbit, snakes, lizards, ground squirrel, pocket gopher, raccoon, mule deer, bats, mice, fox, skunk, bobcat, and mountain lion.

El Capitan Reservoir is located within Diegan coastal sage scrub with areas of oak woodlands and chaparral (San Diego County 2011; SDRWWG 2005; SDRP 2015). The Lower Otay Reservoir, Lake Hodges, and Lake Jennings are located within coastal sage scrub. Sweetwater Reservoir is surrounded by coastal sage scrub and chaparral with riparian forest along stream channels.

10.3.6.5 Non-SWP Reservoir in San Bernardino County

Lake Arrowhead, in San Bernardino County, is used to store SWP water by the Lake Arrowhead Community Services District (County of San Bernardino 2011; LACSD 2014a, 2014b). Lake Arrowhead is located within chaparral, sage scrub, oak woodlands, oak and sycamore woodlands, dogwood tree along the lake, cottonwood and willow forests along stream channels, Ponderosa pine forests, and wetlands. The habitat supports Stellar Jay, blue jay, quail, ducks, western Tanager, Northern Tanager, woodpecker, chickadee, Barn Owl, Bald Eagle, hawks, rattlesnake, coyote, bobcat, Black Bear, Gray Squirrel, Ground Squirrel, chipmunk, raccoon, mountain lion, skunk, and cougar.

10.4 Impact Analysis

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

10.4.1 Potential Mechanisms for Change and Analytical Methods

As described in Chapter 4, Approach to Environmental Analysis, the impact analysis considers changes in terrestrial resources 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 change surface water resources affected by CVP and SWP operations.

10.4.1.1 Changes in CVP and SWP Reservoir Elevations

Changes in surface water elevations at the CVP and SWP reservoirs would influence the extent of the drawdown zone (the area of shoreline between the full inundation elevation and the water level), which can influence the availability and quality of nesting habitat for some ground-nesting birds (e.g., waterfowl) and possibly the prey base for nesting fish-eating raptors (e.g., Bald Eagle and Osprey) in March through June. The creation of barren zones through reservoir drawdown can also affect the ability of wildlife species to access water, which could cause them to be more vulnerable to predation.

As described in Chapter 5, Surface Water Resources and Water Supplies, surface water elevations would be similar in all months and all water year types at Trinity Lake, Shasta Lake, Lake Oroville, Folsom Lake, and New Melones Reservoir under Alternatives 1 through 5 as compared to the No Action Alternative and the Second Basis of Comparison. Surface water elevations would change at San Luis Reservoir under Alternatives 1 through 5 as compared to the No Action Alternative and the Second Basis of Comparison. However, it does not appear that nesting fish-eating raptors or ground-nesting waterfowl use the San Luis Reservoir shoreline during these nesting lifestages (Reclamation 2013). Therefore, changes in CVP and SWP operations under the alternatives would result in similar conditions (within 5 percent change) for terrestrial resources at CVP and SWP reservoirs; and these factors are not analyzed in this EIS.

10.4.1.2 Changes in Rivers Downstream of the CVP and SWP Reservoirs

Operation of the CVP and SWP would influence flow regimes that renew and support adjacent riparian and wetland plant and wildlife communities. For example, certain riparian plants (e.g., willows) require a specific sequence and timing of flow events to prepare the seedbed and to support germination and seedling growth in March through May. Changes in flow that support or interfere with these processes could influence riparian vegetation and its value as wildlife habitat. The analysis is focused on Trinity, Sacramento, Feather, American, and Stanislaus rivers because these rivers are used to convey water from the reservoirs to CVP and SWP water users. Therefore, changes in CVP and SWP operations could result in substantial changes in flow patterns in these rivers. At other reservoirs that are used to store CVP and SWP water supplies (e.g., San Luis Reservoir), the CVP and SWP water are conveyed from the reservoirs in canals or pipelines. The reservoirs may be operated to provide minimum flows to support habitat in streams adjacent to these reservoirs; however, changes in CVP and SWP operations would not affect the minimum instream flow releases. Therefore, changes in terrestrial resources in these streams is not analyzed in this EIS.

Channel maintenance flows to improve adjacent floodplain habitat conditions would occur along Clear Creek under the No Action Alternative and Alternatives 2 and 5, to the extent possible. The high-flow, short-duration pulse flows would be released, if physically possible, from Whiskeytown Lake to mobilize streambed material in Clear Creek in accordance with the 2009 NMFS Biological Opinion (BO).

10.4.1.3 Changes in Sacramento, American, and Stanislaus Rivers Habitats due to Fish Passage at Dams

Fish passage would be provided under the No Action Alternative and Alternative 5 around Shasta, Folsom, and New Melones dams. Salmon runs play an important role in the transfer of large quantities of marine-derived nutrients to adjacent forest ecosystems with substantial effects on plant and wildlife production. Spawning salmon contribute to the release of nutrients into streams through normal metabolic processes, release of gametes during spawning, decay of their carcasses following death, and through consumption of their flesh by predators and scavengers (Merz and Moyle 2006). Returning fish to the upper stream segments, fish passage could influence the forest ecosystem and associated wildlife in the upper watersheds and result in less nutrients along the rivers downstream of the dams. This analysis would assume that the objectives of the 2009 NMFS BO were achieved by 2030, including implementation of fish passage at these CVP reservoirs. However, any changes in nutrients in the stream corridors are expected to be minimal based on information in Merz and Moyle (2006). Therefore, habitat conditions related to changes in nutrient loading associated with fish passage actions would be the same under Alternatives 1 through 5 as under the No Action Alternative and the Second Basis of Comparison. Therefore, this potential change is not analyzed in this EIS.

10.4.1.4 Changes in River and Delta Floodplains

Alternative 4 assumes additional institutional requirements for development within the floodplain and floodways that would require compliance with Endangered Species Act in defining floodplain map revisions, allow for improvements in floodplain management criteria to support natural and beneficial functions, and prohibit new development and substantial improvements to existing development within any designated floodway or within 170 feet of the ordinary high water line of any floodway. However, as described in Chapter 13, Land Use, in 2030, development along major river corridors in the Central Valley would continue to be limited by state regulations implemented by the Central Valley Flood Protection Board and the USACE.

Within the Delta, the floodways are further regulated by the Delta Protection Commission and Delta Stewardship Council to preserve and protect the natural resources of the Delta; and prevent encroachment into Delta floodways. These regulations, as implemented in all alternatives and the Second Basis of Comparison, would prevent development within the Delta floodplains and floodways and in the Sacramento, Feather, American, and San Joaquin rivers corridors upstream of the Delta, as described in Chapter 13. Provisions in Alternative 4 would require additional setbacks along the floodways as compared to other alternatives and the Second Basis of Comparison. The qualitative analysis considers the potential changes in habitat due to these changes in floodplain and floodway development regulations.

Another potential change in Delta habitat would occur under Alternative 4, additional vegetation would remain along the levees in the Delta as compared to conditions under the other alternatives, the No Action Alternative, and the Second Basis of Comparison, as described in Chapter 3, Description of Alternatives. Under Alternatives 1, 2, 3, and 5; the No Action Alternative; and the Second Basis of Comparison existing vegetation would remain along the Delta levees until the levees are repaired. Following repairs, vegetation would be removed along the riparian corridor to improve the structural reliability of the levees in accordance with USACE requirements. It is assumed that by 2030, much of the vegetation would be removed from the levees due to levee repairs.

10.4.1.5 Changes in Flows over Fremont Weir into the Yolo Bypass

All of the alternatives, including the No Action Alternative and the Second Basis of Comparison, include operations of an operable gate at Fremont Weir, as described in Chapter 3, Description of Alternatives. However, the flow patterns into the Yolo Bypass would change based upon the magnitude of flows in the Sacramento River at Fremont Weir.

10.4.1.6 Changes in Wetlands Habitat

The No Action Alternative, Alternatives 1 through 5, and Second Basis of Comparison all include implementation of restoration of more than 10,000 acres of intertidal and associated subtidal wetlands in Suisun Marsh and Cache Slough; 17,000 to 20,000 acres of seasonal floodplain restoration in the Yolo Bypass; and continued delivery of refuge water supplies under the Central Valley Project Improvement Act. There would be no changes in wetlands habitat between Alternatives 1 through 5 as compared to the No Action Alternative, and the Second Basis of Comparison. Therefore, changes to wetland habitats are not analyzed in this EIS.

10.4.1.7 Changes in Delta Habitat

Changes in CVP and SWP operations under the alternatives as compared to the No Action Alternative and Second Basis of Comparison would change the Delta salinity which could affect survival of riparian vegetation. The analysis evaluates changes in salinity by comparing the end of month X2 position.

Another potential change in Delta habitat would occur under Alternative 4, due to additional vegetation along the levees in the Delta as compared to conditions under the other alternatives, the No Action Alternative, and the Second Basis of Comparison, as described in Chapter 3, Description of Alternatives.

10.4.1.8 Changes in Irrigated Agricultural Acreage Habitats in Areas that use CVP and SWP Water

As described in Section 10.3, Affected Environment, agricultural lands provide considerable value to terrestrial wildlife, which varies with crop type and wildlife species. Generally, rice production provides high habitat value for some species because it supports many of the attributes of wetlands. Most notably, flooded rice fields during the growing season provide foraging and nesting habitat for waterfowl and shorebirds, as well as habitat for the federally listed Giant Garter Snake. In the fall and early winter, flooding for rice straw decomposition plays an important role in providing habitat for migrating waterbirds. Other crops, such as alfalfa and irrigated pasture, also provide habitat value, primarily because of their perennial nature and the application of flood irrigation. These crops provide valuable foraging habitat for species such as the state-listed Swainson’s Hawk. Grain crops provide seasonal value to species such as Greater Sandhill Crane and others, but orchards, vineyards, vegetable, and truck crops generally provide relatively low habitat value for terrestrial species.

Changes in CVP and SWP operations under the alternatives could change the extent of irrigated acreage and associated habitats over the long-term average condition and in dry and critical dry years as compared to the No Action Alternative and Second Basis of Comparison, as described in Chapter 12, Agricultural Resources. However, irrigated acreage under Alternatives 1 through 5 would be similar (within 5 percent change) to irrigated acreage under the No Action Alternative and the Second Basis of Comparison. Therefore, there would be no change in terrestrial habitat at the irrigated acreage; and this factor is not analyzed in this EIS.

10.4.1.9 Effects due to Cross Delta 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 and who can make the water available through releasing previously stored water, pumping groundwater instead of using surface water (groundwater substitution); idling crops; 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 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 terrestrial resources 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 conditions related to water transfer actions (Reclamation 2014d). 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.

10.4.2 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. However, the changes to terrestrial resources 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.

10.4.2.1 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, including general plan development, future water management and supply projects, and river and Delta floodplain development.

10.4.2.1.1 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.

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 under the No Action Alternative and the Second Basis of Comparison. However, the CVP and SWP water deliveries would be less under the No Action Alternative as compared to the Second Basis of Comparison, as described in Chapter 5, Surface Water Resources and Water Supplies, which could result in more crop idling.

The Delta estuarine habitat is complex due to the freshwater-saltwater interface that supports numerous terrestrial species that require freshwater conditions primarily in the winter and spring and may withstand periods of higher salinity in the late summer and fall months. Climate change and sea level rise and CVP and SWP operations would change the location of the freshwater-saltwater interface in the Delta which would affect the survivability of vegetation within that area, especially in the western Delta and Suisun Marsh. Operations of the CVP and SWP would continue to maintain freshwater conditions in the spring in accordance with the State Water Resources Control Board Decision 1641. However, higher salinity conditions would occur in the summer months and in the fall of drier years which would affect the types of riparian vegetation in the western Delta and in Suisun Marsh under the No Action Alternative and Second Basis of Comparison in 2030 as compared to recent historical conditions.

10.4.2.1.2 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 terrestrial resources, 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 would affect terrestrial resources, including:

- Habitat Restoration includes 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.
- Sacramento River, American River, and Clear Creek Spawning Gravel Augmentation.
- Battle Creek Restoration.
- Lower American River Flow Management Standard.

10.4.2.1.3 Changes in River and Delta Floodplains

It is assumed that under the No Action Alternative and the Second Basis of Comparison, the State of California would continue to implement flood management projects to reduce flood risks along the Sacramento and San Joaquin rivers and in the Delta (DWR 2013b). These programs would be implemented in a manner that would be coordinated with opportunities to restore or maintain the function of natural systems with consideration of future conditions with climate change and sea level rise. However, terrestrial resources would be changed by 2030 as compared to recent historical conditions.

Terrestrial resources along Delta levees also would be affected through implementation of USACE policies for vegetation on levees. Historically, the USACE has allowed brush and small trees to be located on the waterside of federal flood management project levees if the vegetation would preserve, protect, and/or enhance natural resources, and/or protect rights of Native Americans, while maintaining the safety, structural integrity, and functionality of the levee (DWR 2011). After Hurricane Katrina in 2005, the USACE issued a policy and draft policy guidance to remove substantial vegetation from these levees throughout the nation (USACE 2009). This policy requires federally authorized levee systems that have maintenance agreements with the USACE (including Delta levees along the Sacramento and San Joaquin rivers) and other levees that are eligible for the federal Rehabilitation and Inspection Program (Public Law 84-99) to remove vegetation in the following manner.

- Removal of all vegetation from the upper third of the waterside slope of the levee, the top of the levee, landside slope of the levee, or within 15 feet of the toe of the levee on the landside ("toe" is where the levee slope meets the ground surfaces).
- Removal of all vegetation over 2 inches in diameter on the lower two-thirds of the waterside slope of the levee and within 15 feet of the toe of the levee on the waterside along benches above the water surface.

In 2010, the USACE issued a draft policy guidance letter, *Draft Process for Requesting a Variance from Vegetation Standards for Levees and Floodwalls—75 Federal Register 6364-68* (USACE 2010) that included procedures for State and local agencies to request variances on a site-specific basis. DWR has been in negotiations with USACE to remove vegetation on the upper third of the waterside slope, top, and landside of the levees, and continue to allow vegetation on the lower two-thirds of the waterside slope of the levee and along benches above the water surface (DSC 2011). By 2030, it is anticipated that much of the existing vegetation on the upper third of the waterside slopes, tops, landside slopes, and within 15 feet of the landside toe of the levees would be removed.

By 2030 under the No Action Alternative and the Second Basis of Comparison, development along major river corridors in the Central Valley would continue to be limited by state regulations implemented by the Central Valley Flood Protection Board and the USACE. Within the Delta, the floodways would continue to be regulated by the Delta Protection Commission and Delta Stewardship Council to preserve and protect the natural resources of the Delta; and prevent encroachment into Delta floodways. These requirements would prevent development within the Delta floodplains and floodways and in the Sacramento, Feather, American, and San Joaquin rivers corridors upstream of the Delta.

10.4.3 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.

10.4.3.1 No Action Alternative

As described in Chapter 4, Approach to Environmental Analysis, the No Action Alternative is compared to the Second Basis of Comparison.

10.4.3.1.1 Trinity River Region

Changes in Rivers Downstream of CVP and SWP Reservoirs

River flows in Trinity River downstream of Lewiston Dam in the critical period for terrestrial resources of March through May would be similar under the No Action Alternative and the Second Basis of Comparison, as described in Chapter 5, Surface Water Resources and Water Supplies. Therefore, terrestrial resources habitat conditions along the Trinity River and lower Klamath River riparian corridors would be similar under the No Action Alternative and Second Basis of Comparison.

10.4.3.1.2 Central Valley Region

Changes in Rivers Downstream of CVP and SWP Reservoirs

Flows in the spring months would be similar in the Sacramento River at Keswick and Freeport and American River downstream of Nimbus Dam; increased flows in the Stanislaus River downstream of Goodwin Dam (over 100 percent); and reduced in the Feather River downstream of Thermalito Complex (25 to 30 percent) under the No Action Alternative as compared to the Second Basis of Comparison. This analysis does not include site specific evaluation of all terrestrial resources along these riparian corridors. However, the changes in flows are indicative of the potential for change in the terrestrial resources. Therefore, under the No Action Alternative as compared to the Second Basis of Comparison, the potential for similar or improved terrestrial resources would occur along the Sacramento, American, and Stanislaus rivers; and the potential for reduced terrestrial resources would occur along the Feather River.

Monthly Clear Creek flows under the No Action Alternative as compared to the Second Basis of Comparison are identical except in May. In May, under the No Action Alternative, flows are up to 40.7 percent higher than under the Second Basis of Comparison in accordance with the 2009 NMFS BO. Terrestrial resources habitat in the floodplains of lower Clear Creek would be slightly improved under the No Action Alternative as compared to the Second Basis of Comparison.

Potential Effects on Special Status Species

Habitat changes along the riparian corridors related to changes in spring flows that support riparian vegetation recruitment would affect numerous bird species that use the riparian corridor, including Black Tern, Least Bell’s Vireo, Least

Bittern, Swainson’s Hawk, Tricolored Blackbird, Western Yellow-billed Cuckoo, White-tailed Kite, Yellow Warbler, Ringtail, Western Pond Turtle, Valley Elderberry Longhorn Beetle, and Delta Button-celery. Potential adverse effects could occur to these species due to reduced flows in the spring months on the Feather River.

Changes in River and Delta Floodplains

It is assumed that under the No Action Alternative and the Second Basis of Comparison, the State of California would continue to implement flood management projects to reduce flood risks along the Sacramento and San Joaquin rivers and in the Delta with consideration for opportunities to restore or maintain the function of natural ecosystems. The related terrestrial habitat conditions would be similar under the No Action Alternative and the Second Basis of Comparison.

Changes in Flows over Fremont Weir into the Yolo Bypass

Flows from the Sacramento River into the Yolo Bypass at Fremont Weir are similar under the No Action Alternative and the Second Basis of Comparison; therefore, terrestrial habitat could be similar.

Changes in Delta Habitat due to Changes in Water Quality

Under the No Action Alternative, the freshwater interface would be similar to conditions under the Second Basis of Comparison in all months in below normal, dry, and critical dry years; and from January through August in wet and above normal years. In the fall months in wet years, the X2 location would be 9 to 14 kilometers towards the west in September through December under the No Action Alternative as compared to the Second Basis of Comparison.

Potential Effects on Special Status Species

Lower Delta salinity under the No Action Alternative as compared to the Second Basis of Comparison would improve habitat for Bolander’s Water Hemlock, Delta Button-celery, Delta Tule Pea, Mason’s Lilaeopsis, Soft Birds-beak, Suisun Marsh Aster, Salt Marsh Harvest Mouse, and Suisun Shrew.

Effects Related to Cross Delta Water Transfers

Potential effects to terrestrial 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 2014d). Potential effects to terrestrial resources were identified as changes in stream flows due declining groundwater levels along streams due to the use of groundwater substitution to provide transfer water. The analysis indicated that these potential impacts would not be substantial due to the inclusion of a monitoring and mitigation program.

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.

10.4.3.2 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 water resource conditions under Alternative 1 are identical to water resource conditions under the Second Basis of Comparison; Alternative 1 is only compared to the No Action Alternative.

10.4.3.2.1 Alternative 1 Compared to the No Action Alternative

Trinity River Region

Changes in Rivers Downstream of CVP and SWP Reservoirs

River flows in Trinity River downstream of Lewiston Dam in the critical period for terrestrial resources of March through May would be similar under Alternative 1 and the No Action Alternative. Therefore, terrestrial resources habitat conditions along the Trinity River and lower Klamath River riparian corridors would be similar under Alternative 1 as compared to the No Action Alternative.

Central Valley Region

Changes in Rivers Downstream of CVP and SWP Reservoirs

Flows in the spring months would be similar in the Sacramento River at Keswick and Freeport and American River downstream of Nimbus Dam; increased in the Feather River downstream of Thermalito Complex (35 percent); and reduced flows in the Stanislaus River downstream of Goodwin Dam (60 percent) under Alternative 1 as compared to the No Action Alternative. This analysis does not include site specific evaluation of all terrestrial resources along these riparian corridors. However, the changes in flows are indicative of the potential for change in the terrestrial resources. Therefore, under Alternative 1 as compared to the No Action Alternative, the potential for similar or improved terrestrial resources would occur along the Sacramento, American, and Feather rivers; and the potential for reduced terrestrial resources would occur along the Stanislaus River.

Monthly Clear Creek flows under Alternative 1 as compared to the No Action Alternative are identical except in May. In May, under Alternative 1, flows are up to 29 percent lower as compared to the No Action Alternative. Terrestrial resources habitat in the floodplains of lower Clear Creek could be decreased under Alternative 1 as compared to the No Action Alternative.

Potential Effects on Special Status Species

Habitat changes along the riparian corridors related to changes in spring flows that support riparian vegetation recruitment would affect numerous bird species that use the riparian corridor, including Black Tern, Least Bell's Vireo, Least Bittern, Swainson's Hawk, Tricolored Blackbird, Western Yellow-billed Cuckoo, White-tailed Kite, Yellow Warbler, Ringtail, Western Pond Turtle, Valley Elderberry Longhorn Beetle, and Delta Button-celery. Potential adverse effects could occur to these species due to reduced flows in the spring months on the Stanislaus River.

Changes in River and Delta Floodplains

It is assumed that under Alternative 1 and the No Action Alternative, the State of California would continue to implement flood management projects to reduce flood risks along the Sacramento and San Joaquin rivers and in the Delta with consideration for opportunities to restore or maintain the function of natural ecosystems. The related terrestrial habitat conditions that would occur due to implementation of the flood management projects would be the same under Alternative 1 and the No Action Alternative.

Changes in Flows over Fremont Weir into the Yolo Bypass

Flows from the Sacramento River into the Yolo Bypass at Fremont Weir would be similar or higher under Alternative 1 as compared to the No Action Alternative; therefore, terrestrial habitat could be similar or increased depending upon the flow pattern.

Changes in Delta Habitat due to Changes in Water Quality

Under Alternative 1, the freshwater interface would be similar to conditions under the No Action Alternative in all months in below normal, dry, and critical dry years; and from January through August in wet and above normal years. In the fall months in wet years, the X2 location would be 9 to 14 kilometers towards the east in September through December under Alternative 1 as compared to the No Action Alternative. This could adversely affect terrestrial species that have acclimated to freshwater conditions.

Potential Effects on Special Status Species

Higher Delta salinity under Alternative 1 as compared to the No Action Alternative would reduce habitat conditions for Bolander’s Water Hemlock, Delta Button-celery, Delta Tule Pea, Mason’s Lilaeopsis, Soft Birds-beak, Suisun Marsh Aster, Salt Marsh Harvest Mouse, and Suisun Shrew.

Effects Related to Cross Delta Water Transfers

Potential effects to terrestrial 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 2014d). Potential effects to terrestrial resources were identified as changes in stream flows due declining groundwater levels along streams due to the use of groundwater substitution to provide transfer water. The analysis indicated that these potential impacts would not be substantial due to the inclusion of a monitoring and mitigation program.

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.

10.4.3.2.2 Alternative 1 Compared to the Second Basis of Comparison

Alternative 1 is identical to the Second Basis of Comparison.

10.4.3.3 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.

10.4.3.3.1 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 in terrestrial resources under Alternative 2 as compared to the Second Basis of Comparison would be the same as the impacts described in Section 10.4.3.1, No Action Alternative.

10.4.3.4 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 with modified Old and Middle River flow criteria and New Melones Reservoir operations. As described in Chapter 4, Approach to Environmental Analysis, Alternative 3 is compared to the No Action Alternative and the Second Basis of Comparison.

10.4.3.4.1 Alternative 3 Compared to the No Action Alternative

Trinity River Region

Changes in Rivers Downstream of CVP and SWP Reservoirs

River flows in Trinity River downstream of Lewiston Dam in the critical period for terrestrial resources of March through May would be similar under Alternative conditions along the Trinity River and lower Klamath River riparian corridors would be similar under Alternative 3 as compared to the No Action Alternative.

Central Valley Region

Changes in Rivers Downstream of CVP and SWP Reservoirs

Flows in the spring months would be similar in the Sacramento River at Keswick and Freeport and American River downstream of Nimbus Dam; increased in the Feather River downstream of Thermalito Complex (25 to 35 percent); and reduced flows in the Stanislaus River downstream of Goodwin Dam (60 percent) under Alternative 3 as compared to the No Action Alternative. This analysis does not include site specific evaluation of all terrestrial resources along these riparian corridors. However, the changes in flows are indicative of the potential for change in the terrestrial resources. Therefore, under Alternative 3 as compared to the No Action Alternative, the potential for similar or improved terrestrial resources would occur along the Sacramento, American, and Feather rivers; and the potential for reduced terrestrial resources would occur along the Stanislaus River.

Monthly Clear Creek flows under Alternative 3 as compared to the No Action Alternative are identical except in May. In May, under Alternative 3, flows are up to 29 percent lower as compared to the No Action Alternative. Terrestrial resources habitat in the floodplains of lower Clear Creek would be decreased under Alternative 3 as compared to the No Action Alternative.

Potential Effects on Special Status Species

Habitat changes along the riparian corridors related to changes in spring flows that support riparian vegetation recruitment would affect numerous bird species that use the riparian corridor, including Black Tern, Least Bell's Vireo, Least Bittern, Swainson's Hawk, Tricolored Blackbird, Western Yellow-billed Cuckoo, White-tailed Kite, Yellow Warbler, Ringtail, Western Pond Turtle, Valley Elderberry Longhorn Beetle, and Delta Button-celery. Potential adverse effects could occur to these species due to reduced flows in the spring months on the Stanislaus River.

Changes in River and Delta Floodplains

It is assumed that under Alternative 3 and the No Action Alternative, the State of California would continue to implement flood management projects to reduce flood risks along the Sacramento and San Joaquin rivers and in the Delta with consideration for opportunities to restore or maintain the function of natural ecosystems. The related terrestrial habitat that would occur due to implementation of the flood management projects would be the same under Alternative 3 and the No Action Alternative.

Changes in Flows over Fremont Weir into the Yolo Bypass

Flows from the Sacramento River into the Yolo Bypass at Fremont Weir would be similar or higher (10 to 30 percent) under Alternative 3 as compared to the No Action Alternative. Terrestrial habitat could be similar or increased due to the flow patterns.

Changes in Delta Habitat due to Changes in Water Quality

Under Alternative 3, the freshwater interface would be similar to conditions under the No Action Alternative in all months in below normal, dry, and critical dry years; and from January through August in wet and above normal years. In the fall months in wet years, the X2 location would be 9 to 14 kilometers towards the east in September through December under Alternative 3 as compared to the No Action Alternative.

Potential Effects on Special Status Species

Higher Delta salinity under Alternative 3 as compared to the No Action Alternative would reduce habitat conditions for Bolander's Water Hemlock, Delta Button-celery, Delta Tule Pea, Mason's Lilaeopsis, Soft Birds-beak, Suisun Marsh Aster, Salt Marsh Harvest Mouse, and Suisun Shrew.

Effects Related to Cross Delta Water Transfers

Potential effects to terrestrial 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 2014d). Potential effects to terrestrial resources were identified as changes in stream flows due declining groundwater levels along streams due to the use of groundwater substitution to provide transfer water. The analysis indicated that these potential impacts would not be substantial due to the inclusion of a monitoring and mitigation program.

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.

10.4.3.4.2 Alternative 3 Compared to the Second Basis of Comparison

Trinity River Region

Changes in Rivers Downstream of CVP and SWP Reservoirs

River flows in Trinity River downstream of Lewiston Dam in the critical period for terrestrial resources of March through May would be similar under Alternative 3 and the Second Basis of Comparison. Therefore, terrestrial resources habitat conditions along the Trinity River and lower Klamath River riparian corridors would be similar under Alternative 3 as compared to the Second Basis of Comparison.

Central Valley Region

Changes in Rivers Downstream of CVP and SWP Reservoirs

Flows in the spring months would be similar in the Sacramento River at Keswick and Freeport, Feather River downstream of Thermalito Complex, and American River downstream of Nimbus Dam; and reduced flows in the Stanislaus River downstream of Goodwin Dam (6 to 52 percent, depending upon water year type) under Alternative 3 as compared to the Second Basis of Comparison. This analysis does not include site specific evaluation of all terrestrial resources along these riparian corridors. However, the changes in flows are indicative of the potential for change in the terrestrial resources. Therefore, under Alternative 3 as compared to the Second Basis of Comparison, the potential for similar terrestrial resources habitat would occur along the Sacramento, American, and Feather rivers; and the potential for reduced terrestrial resources would occur along the Stanislaus River.

Monthly Clear Creek flows under Alternative 3 as compared to the Second Basis of Comparison are identical under Alternative 3; therefore, terrestrial resources habitat in the floodplains of lower Clear Creek would be similar under Alternative 3 as compared to the Second Basis of Comparison.

Potential Effects on Special Status Species

Habitat changes along the riparian corridors related to changes in spring flows that support riparian vegetation recruitment would affect numerous bird species that use the riparian corridor, including Black Tern, Least Bell's Vireo, Least Bittern, Swainson's Hawk, Tricolored Blackbird, Western Yellow-billed Cuckoo, White-tailed Kite, Yellow Warbler, Ringtail, Western Pond Turtle, Valley Elderberry Longhorn Beetle, and Delta Button-celery. Potential adverse effects could occur to these species due to reduced flows in the spring months on the Stanislaus River.

Changes in River and Delta Floodplains

It is assumed that under Alternative 3 and the Second Basis of Comparison, the State of California would continue to implement flood management projects to reduce flood risks along the Sacramento and San Joaquin rivers and in the Delta with consideration for opportunities to restore or maintain the function of natural ecosystems. The related terrestrial habitat conditions that would occur due to implementation of the flood management projects would be the same under Alternative 3 and the Second Basis of Comparison.

Changes in Flows over Fremont Weir into the Yolo Bypass

Flows from the Sacramento River into the Yolo Bypass at Fremont Weir and associated terrestrial habitat would be similar under Alternative 3 as compared to the Second Basis of Comparison.

Changes in Delta Habitat due to Changes in Water Quality

Under Alternative 3, the freshwater-saltwater interface would be similar to conditions under the Second Basis of Comparison in all months and in all water year types.

Potential Effects on Special Status Species

Delta salinity under Alternative 3 as compared to the Second Basis of Comparison would result in similar habitat conditions for Bolander's Water Hemlock, Delta Button-celery, Delta Tule Pea, Mason's Lilaeopsis, Soft Birds-beak, Suisun Marsh Aster, Salt Marsh Harvest Mouse, and Suisun Shrew.

Effects Related to Cross Delta Water Transfers

Potential effects to terrestrial 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 2014d). Potential effects to terrestrial resources were identified as changes in stream flows due declining groundwater levels along streams due to the use of groundwater substitution to provide transfer water. The analysis indicated that these potential impacts would not be substantial due to the inclusion of a monitoring and mitigation program.

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 as compared to the Second Basis of Comparison.

10.4.3.5 Alternative 4

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. Alternative 4 also includes additional institutional requirements for development within the floodplain and floodways, including the following items.

- Compliance with Endangered Species Act in defining floodplain map revisions.
- Improvements in floodplain management criteria to support natural and beneficial functions.
- Prohibition of new development and substantial improvements to existing development within any designated floodway or within 170 feet of the ordinary high water line of any floodway.
- Modification of USACE requirements to remove vegetation along portions of the waterside of levees, as described in Section 10.4.3.1, No Action Alternative.

Alternative 4 is compared to the No Action Alternative and the Second Basis of Comparison.

10.4.3.5.1 Alternative 4 Compared to the No Action Alternative

These actions would not change CVP and SWP operations; and would only affect the Changes in River and Delta Floodplains. Therefore, changes in terrestrial resources due to changes in CVP and SWP under Alternative 4 as compared to the No Action Alternative would be the same as the impacts described in Section 10.4.3.2.1, Alternative 1 Compared to the No Action Alternative.

Changes in River and Delta Floodplains

It is assumed that under the No Action Alternative, the State of California would continue to implement flood management projects to reduce flood risks along the Sacramento and San Joaquin rivers and in the Delta with consideration for opportunities to restore or maintain the function of natural ecosystems. The USACE policies for vegetation on levees would be implemented; and by 2030, much of the vegetation along Delta channels would have been removed.

Under Alternative 4, implementation of institutional provisions would result in development of the floodplains and floodways, especially in the Delta, that would be similar to development under the No Action Alternative. Under the No Action Alternative, as described in Chapter 13, Land Use, development along major river corridors in the Central Valley would be limited by state regulations implemented by the Central Valley Flood Protection Board and the USACE. Within the Delta, the floodways are further regulated by the Delta Protection Commission and Delta Stewardship Council to preserve and protect the natural resources of the Delta; and prevent encroachment into Delta floodways. These regulations would prevent development within the Delta floodplains and floodways and in the Sacramento, Feather, American, and San Joaquin rivers corridors upstream of the Delta. Under Alternative 4, development would be prevented within 170 feet from the ordinary high water line of any floodway. This setback area could provide opportunities to establish vegetative corridors.

Under Alternative 4 and the No Action Alternative, vegetation management along the Delta levees would include removal of all vegetation from the upper third of the waterside slope of the levee, the top of the levee, landside slope of the levee, and within 15 feet on the landside of the toe of the levee ("toe" is where the levee slope meets the ground surfaces). Under Alternative 4, vegetation could be maintained on the lower two-thirds of the waterside slope of the levee and within 15 feet of the toe of the levee on the waterside along benches above the water surface. This would provide shaded riverine aquatic habitat and riparian vegetation along many of the Delta channels as compared to the No Action Alternative.

Overall, Alternative 4 would result in increased vegetation along the riparian corridors related to recruitment of riparian vegetation in the Delta watershed as compared to the No Action Alternative.

10.4.3.5.2 Alternative 4 Compared to the Second Basis of Comparison

The changes in river and Delta floodplain actions would not change CVP and SWP operations which would be identical under Alternative 4 and under the Second Basis of Comparison.

Changes in River and Delta Floodplains

It is assumed that under the Second Basis of Comparison, the State of California would continue to implement flood management projects to reduce flood risks along the Sacramento and San Joaquin rivers and in the Delta with consideration for opportunities to restore or maintain the function of natural ecosystems. The USACE policies for vegetation on levees would be implemented; and by 2030, much of the vegetation along Delta channels would have been removed.

Under Alternative 4, implementation of institutional provisions would result in development of the floodplains and floodways, especially in the Delta, that would be similar to development under the Second Basis of Comparison. Under the Second Basis of Comparison, as described in Chapter 13, Land Use, development along major river corridors in the Central Valley would be limited by state regulations implemented by the Central Valley Flood Protection Board and the USACE. Within the Delta, the floodways are further regulated by the Delta Protection Commission and Delta Stewardship Council to preserve and protect the natural resources of the Delta; and prevent encroachment into Delta floodways. These regulations would prevent development within the Delta floodplains and floodways and in the Sacramento, Feather, American, and San Joaquin rivers corridors upstream of the Delta. Under Alternative 4, development would be prevented within 170 feet from the ordinary high water line of any floodway. This setback area could provide opportunities to establish vegetative corridors.

Under Alternative 4 and the Second Basis of Comparison, vegetation management along the Delta levees would include removal of all vegetation from the upper third of the waterside slope of the levee, the top of the levee, landside slope of the levee, and within 15 feet on the landside of the toe of the levee ("toe" is where the levee slope meets the ground surfaces). Under Alternative 4, vegetation could be maintained on the lower two-thirds of the waterside slope of the levee and within 15 feet of the toe of the levee on the waterside along benches above the water surface. This would provide shaded riverine aquatic habitat and riparian vegetation along many of the Delta channels as compared to the Second Basis of Comparison.

Overall, Alternative 4 would result in increased terrestrial resources along the riparian corridors related to recruitment of riparian vegetation in the Delta watershed as compared to the Second Basis of Comparison.

10.4.3.6 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.

10.4.3.6.1 Alternative 5 Compared to the No Action Alternative

Trinity River Region

Changes in Rivers Downstream of CVP and SWP Reservoirs

River flows in Trinity River downstream of Lewiston Dam in the critical period for terrestrial resources of March through May would be similar under Alternative 5 and the No Action Alternative. Therefore, terrestrial resources habitat conditions along the Trinity River and lower Klamath River riparian corridors would be similar under Alternative 5 as compared to the No Action Alternative.

Central Valley Region

Changes in Rivers Downstream of CVP and SWP Reservoirs

Flows in the spring months would be similar in the Sacramento River at Keswick and Freeport, Feather River downstream of Thermalito Complex, American River downstream of Nimbus Dam; and flows in the Stanislaus River downstream of Goodwin Dam would increase 22 to 40 percent in some spring months and 8 to 18 percent in other spring months, depending upon water year type under Alternative 5 as compared to the No Action Alternative. This analysis does not include site specific evaluation of all terrestrial resources along these riparian corridors. However, the changes in flows are indicative of the potential for change in the terrestrial resources. Therefore, under Alternative 5 as compared to the No Action Alternative, the potential for similar or improved terrestrial resources habitat would occur along the Sacramento, Feather, and American rivers; and the potential for both increased and reduced terrestrial resources habitat would occur along the Stanislaus River.

Monthly Clear Creek flows would be identical under Alternative 5 as compared to the No Action Alternative; therefore, terrestrial resources habitat in the floodplains of lower Clear Creek would be similar under Alternative 5 as compared to the Second Basis of Comparison.

Potential Effects on Special Status Species

Habitat changes along the riparian corridors related to changes in spring flows that support riparian vegetation recruitment would affect numerous bird species that use the riparian corridor, including Black Tern, Least Bell's Vireo, Least Bittern, Swainson's Hawk, Tricolored Blackbird, Western Yellow-billed Cuckoo, White-tailed Kite, Yellow Warbler, Ringtail, Western Pond Turtle, Valley Elderberry Longhorn Beetle, and Delta Button-celery. Potential adverse effects could occur to these species due to reduced flows in the spring months on the Stanislaus River.

Changes in River and Delta Floodplains

It is assumed that under Alternative 5 and the No Action Alternative, the State of California would continue to implement flood management projects to reduce flood risks along the Sacramento and San Joaquin rivers and in the Delta with consideration for opportunities to restore or maintain the function of natural ecosystems. The related terrestrial habitat conditions that would occur due to implementation of the flood management projects would be the same under Alternative 5 and the No Action Alternative.

Changes in Flows over Fremont Weir into the Yolo Bypass

Flows from the Sacramento River into the Yolo Bypass at Fremont Weir and associated terrestrial habitat would be similar under Alternative 5 as compared to the No Action Alternative.

Changes in Delta Habitat due to Changes in Water Quality

Under Alternative 5, the freshwater interface would be similar to conditions under the No Action Alternative in all months and in all water year types.

Potential Effects on Special Status Species

Similar Delta salinity under Alternative 5 as compared to the No Action Alternative would result in similar habitat conditions for Bolander's Water Hemlock, Delta Button-celery, Delta Tule Pea, Mason's Lilaeopsis, Soft Birds-beak, Suisun Marsh Aster, Salt Marsh Harvest Mouse, and Suisun Shrew.

Effects Related to Cross Delta Water Transfers

Potential effects to terrestrial 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 2014d). Potential effects to terrestrial resources were identified as changes in stream flows due declining groundwater levels along streams due to the use of groundwater substitution to provide transfer water. The analysis indicated that these potential impacts would not be substantial due to the inclusion of a monitoring and mitigation program.

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.

10.4.3.6.2 Alternative 5 Compared to the Second Basis of Comparison

Trinity River Region

Changes in Rivers Downstream of CVP and SWP Reservoirs

River flows in Trinity River downstream of Lewiston Dam in the critical period for terrestrial resources of March through May would be similar under Alternative 5 and the Second Basis of Comparison. Therefore, terrestrial resources habitat conditions along the Trinity River and lower Klamath River riparian corridors would be similar under Alternative 5 as compared to the Second Basis of Comparison.

Central Valley Region

Changes in Rivers Downstream of CVP and SWP Reservoirs

Flows in the spring months would be similar in the American River downstream of Nimbus Dam; increased flows in the Stanislaus River downstream of Goodwin Dam (over 100 percent); and reduced in the Sacramento River at Keswick and Freeport and Feather River downstream of Thermalito Complex (8 to 13 percent and 25 to 45 percent, respectively) under Alternative 5 as compared to the Second Basis of Comparison. This analysis does not include site specific evaluation of all terrestrial resources along these riparian corridors. However, the changes in flows are indicative of the potential for change in the terrestrial resources. Therefore, under Alternative 5 as compared to the Second Basis of Comparison, the potential for similar or improved terrestrial resources habitat would occur along the American and Stanislaus rivers; and the potential for reduced terrestrial resources habitat would occur along the Sacramento and Feather rivers.

Monthly Clear Creek flows under Alternative 5 as compared to the Second Basis of Comparison are identical except in May. In May, under Alternative 5, flows are up to 40.7 percent higher than under the Second Basis of Comparison in accordance with the 2009 NMFS BO. Terrestrial resources habitat in the floodplains of lower Clear Creek would be improved under Alternative 5 as compared to the Second Basis of Comparison.

Potential Effects on Special Status Species

Habitat changes along the riparian corridors related to changes in spring flows that support riparian vegetation recruitment would affect numerous bird species that use the riparian corridor, including Black Tern, Least Bell's Vireo, Least Bittern, Swainson's Hawk, Tricolored Blackbird, Western Yellow-billed Cuckoo, White-tailed Kite, Yellow Warbler, Ringtail, Western Pond Turtle, Valley Elderberry Longhorn Beetle, and Delta Button-celery. Potential adverse effects could occur to these species due to reduced flows in the spring months on the Sacramento and Feather rivers.

Changes in River and Delta Floodplains

It is assumed that under Alternative 5 and the Second Basis of Comparison, the State of California would continue to implement flood management projects to reduce flood risks along the Sacramento and San Joaquin rivers and in the Delta with consideration for opportunities to restore or maintain the function of natural ecosystems. The related terrestrial habitat conditions that would occur due to implementation of the flood management projects would be the same under Alternative 5 and the Second Basis of Comparison.

Changes in Flows over Fremont Weir into the Yolo Bypass

Flows from the Sacramento River into the Yolo Bypass at Fremont Weir would similar or lower (24 percent) under Alternative 5 as compared to the Second Basis of Comparison. The decrease in the extent of flow inundation in the Yolo Bypass could cause degradation of terrestrial habitat as compared to the Second Basis of Comparison.

Changes in Delta Habitat due to Changes in Water Quality

Under Alternative 5, the freshwater interface would be similar to conditions under the Second Basis of Comparison in all months in below normal, dry, and critical dry years; and from January through August in wet and above normal years. In the fall months in wet years, the X2 location would be 9 to 14 kilometers towards the west in September through December under Alternative 5 as compared to the Second Basis of Comparison.

Potential Effects on Special Status Species

Lower Delta salinity under Alternative 5 as compared to the Second Basis of Comparison would improve habitat conditions for Bolander’s Water Hemlock, Delta Button-celery, Delta Tule Pea, Mason’s Lilaeopsis, Soft Birds-beak, Suisun Marsh Aster, Salt Marsh Harvest Mouse, and Suisun Shrew.

Effects Related to Cross Delta Water Transfers

Potential effects to terrestrial 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 2014d). Potential effects to terrestrial resources were identified as changes in stream flows due declining groundwater levels along streams due to the use of groundwater substitution to provide transfer water. The analysis indicated that these potential impacts would not be substantial due to the inclusion of a monitoring and mitigation program.

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 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 Alternative 5 as compared to the Second Basis of Comparison.

10.4.3.7 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 10.2 and 10.3.

Table 10.2 Comparison of Alternatives 1 through 5 to No Action Alternative

Alternative	Potential Change	Consideration for Mitigation Measures
Alternative 1	Similar or increased flows along Trinity, Sacramento, American, and Feather rivers in the spring to support riparian terrestrial habitat. Reduced flows along the Stanislaus River in the spring; therefore, could be reduced terrestrial habitat conditions. Similar terrestrial conditions in Yolo Bypass related to water that flows from the Sacramento River at the Fremont Weir. Increased salt water habitat in the western Delta in the fall months of wet and above normal water years could adversely affect species that have acclimated to freshwater conditions.	No mitigation measures identified at this time to reduce flow reduction impacts on the Stanislaus River, and adverse impacts due to increased salinity in the western Delta in the fall months of wet and above normal water year types.
Alternative 2	No effects on terrestrial resources.	None needed
Alternative 3	Similar or increased flows along Trinity, Sacramento, American, and Feather rivers in the spring to support riparian terrestrial habitat. Reduced flows along the Stanislaus River in the spring; therefore, could be reduced terrestrial habitat conditions. Similar or improved terrestrial conditions in Yolo Bypass related to water that flows from the Sacramento River at the Fremont Weir. Increased salt water habitat in the western Delta in the fall months of wet and above normal water years could adversely affect species that have acclimated to freshwater conditions.	No mitigation measures identified at this time to reduce flow reduction impacts on the Stanislaus River, and adverse impacts due to increased salinity in the western Delta in the fall months of wet and above normal water year types.
Alternative 4	Same effects as described for Alternative 1 compared to the No Action Alternative; except for increased terrestrial vegetation along the riparian corridors related to recruitment of riparian vegetation.	No mitigation measures identified at this time to reduce flow reduction impacts on the Stanislaus River, and adverse impacts due to increased salinity in the western Delta in the fall months of wet and above normal water year types.

Alternative	Potential Change	Consideration for Mitigation Measures
Alternative 5	Similar flows along Trinity, Sacramento, American, and Feather rivers in the spring to support riparian terrestrial habitat. Increased flows along the Stanislaus River in the spring; therefore, could be improved terrestrial habitat conditions. Similar terrestrial conditions in Yolo Bypass related to water that flows from the Sacramento River at the Fremont Weir. Similar freshwater and salt water habitats.	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 No Action Alternative are considered to be “similar.”

Table 10.3 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	Similar or increased flows along Trinity, Sacramento, American, and Stanislaus rivers in the spring to support riparian terrestrial habitat. Reduced flows along the Feather River in the spring; therefore, could be reduced terrestrial habitat conditions. Similar terrestrial conditions in Yolo Bypass related to water that flows from the Sacramento River at the Fremont Weir. Increased freshwater habitat in the western Delta.	Not considered for this comparison.
Alternative 1	No effects on terrestrial resources.	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	Similar or increased flows along Trinity, Sacramento, American, and Feather rivers in the spring to support riparian terrestrial habitat. Reduced flows along the Stanislaus River in the spring; therefore, could be reduced terrestrial habitat conditions. Similar terrestrial conditions in Yolo Bypass related to water that flows from the Sacramento River at the Fremont Weir. Similar freshwater and salt water habitats.	Not considered for this comparison.
Alternative 4	Similar effects except for increased terrestrial vegetation along the riparian corridors related to recruitment of riparian vegetation.	Not considered for this comparison.

Alternative	Potential Change	Consideration for Mitigation Measures
Alternative 5	Similar or increased flows along Trinity, American, and Stanislaus rivers in the spring to support riparian terrestrial habitat. Reduced flows along the Sacramento and Feather rivers in the spring; therefore, could be reduced terrestrial habitat conditions. Similar or decreased terrestrial conditions in Yolo Bypass related to similar or lower water that flows from the Sacramento River at the Fremont Weir. Increased freshwater habitat in the western Delta.	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 No Action Alternative are considered to be "similar."

10.4.3.8 Potential Mitigation Measures

Mitigation measures are included in EISs to avoid, minimize, rectify, reduce, eliminate, or compensate for adverse environmental effects of alternatives as compared to the No Action Alternative. Mitigation measures are not included in this EIS 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.

Changes in CVP and SWP operations under Alternatives 1, 3, and 4 as compared to the No Action Alternative would result in adverse changes in terrestrial resources along Stanislaus River when spring flows are less than under the No Action Alternative; and when the salinity increases in the western Delta. However, mitigation measures have not been identified at this time to reduce the adverse effects of flow reductions in the spring on the Stanislaus River and of increased salinity in the western Delta in the fall months of wet and above normal water year types under Alternatives 1, 3, and 4.

10.4.3.9 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 Terrestrial Resources are summarized in Table 10.4.

Table 10.4 Summary of Cumulative Effects on Terrestrial 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 and in All Alternatives in Year 2030	Consistent with Affected Environment conditions plus: 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 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): - 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 - General plans for 2030. - Trinity River Restoration Program. - Central Valley Project Improvement Act programs - Folsom Dam Water Control Manual Update - FERC Relicensing for the Middle Fork of the American River Project - San Joaquin River Restoration Program - Contra Loma Recreation Resource Management Plan - San Luis Reservoir State Recreation Area Resource Management Plan/General Plan	<u>These effects would be the same under all alternatives.</u> Climate change and sea level rise and development under the general plans are anticipated to reduce carryover storage in reservoirs and changes in stream flow patterns in a manner that would change shoreline, riparian, and floodplain habitat. Other actions, including restoration projects, FERC relicensing projects, and some future projects to improve water quality and/or habitat are anticipated to improve shoreline, riparian, and floodplain habitat.
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): - Bay-Delta Water Quality Control Plan Update - FERC Relicensing Projects - Bay Delta Conservation Plan (including the California WaterFix alternative) - Shasta Lake Water Resources, North-of-the-Delta Offstream Storage, Los Vaqueros Reservoir Expansion Phase 2, and Upper San Joaquin River Basin Storage Investigations - El Dorado Water and Power Authority Supplemental Water Rights Project - Semitropic Water Storage District Delta Wetlands - North Bay Aqueduct Alternative Intake - Irrigated Lands Regulatory Program	<u>These effects would be the same under all alternatives.</u> Some of the future reasonably foreseeable actions to improve water quality and FERC Relicensing projects would improve shoreline, riparian, and floodplain habitat. Other future reasonably foreseeable actions, such as expanded or new reservoirs, would reduce some types of terrestrial habitat and increase other types of terrestrial habitat within the reservoir area.

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 BO Full implementation of the USACE vegetation standards for levees	Implementation of No Action Alternative with future reasonably foreseeable actions would result in changes in stream flows and levee vegetation policies that would result in changes to related terrestrial resources as compared to conditions prior to the BOs. Reduced riparian habitat along levees within the federally authorized levee systems that have maintenance agreements with the USACE as compared to recent 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) Full implementation of the USACE vegetation standards for levees	Implementation of Alternative 1 with future reasonably foreseeable actions would result in changes in stream flows along the Stanislaus River in all water year types, and in salinity in the western Delta fall months of wet and above normal water year types that could result in adverse terrestrial conditions as compared to the No Action Alternative with the added actions. Similar riparian habitat along levees within the federally authorized levee systems that have maintenance agreements with the USACE as compared to the No Action Alternative with the added 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 No implementation of structural improvements or other actions that require further study to develop a more detailed action description. Full implementation of the USACE vegetation standards for levees	Implementation of Alternative 2 with future reasonably foreseeable actions for terrestrial resources would be the same as for the No Action Alternative with the added actions.

Scenarios	Actions	Cumulative Effects of 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) Slight increase in positive Old and Middle River flows in the winter and spring months Full implementation of the USACE vegetation standards for levees	Implementation of Alternative 3 with future reasonably foreseeable action would result in changes in stream flows along the Stanislaus River in all water year types, and in salinity in the western Delta fall months of wet and above normal water year types that could result in adverse terrestrial conditions as compared to the No Action Alternative with the added actions. Similar riparian habitat along levees within the federally authorized levee systems that have maintenance agreements with the USACE as compared to the No Action Alternative with the added actions.
Alternative 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) No implementation of the USACE vegetation standards for levees	Implementation of Alternative 4 with future reasonably foreseeable actions would result in changes in stream flows along the Stanislaus River in all water year types, and in salinity in the western Delta fall months of wet and above normal water year types that could result in adverse terrestrial conditions as compared to the No Action Alternative with the added actions. Implementation of Alternative 4 also would result in increased riparian habitat along effected levees Increased riparian habitat along levees within the federally authorized levee systems that have maintenance agreements with the USACE as compared to the No Action Alternative with the added actions.
Alternative 5 with Associated Cumulative Effects Actions in Year 20530	Full implementation of the 2008 USFWS BO and 2009 NMFS BO Positive Old and Middle River flows and increased Delta outflow in spring months Full implementation of the USACE vegetation standards for levees	Implementation of Alternative 5 with future reasonably foreseeable actions for terrestrial resources would be similar as under the No Action Alternative with the added actions.

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Chapter 11

Geology and Soils Resources

11.1 Introduction

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

11.2 Regulatory Environment and Compliance Requirements

Potential actions that could be implemented under the alternatives evaluated in this EIS could affect reservoirs, streams, and lands served by CVP and SWP water supplies located on lands affected by seismic, landslide, and liquefaction hazards; subsidence; and unstable soils. 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 Analysis.

11.3 Affected Environment

This section describes the geological, regional seismic, and soils characteristics and subsidence potential that could be potentially affected by the implementation of the alternatives considered in this EIS. Changes in soils characteristics 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. Geomorphic provinces in California are shown on Figure 11.1.

11.3.1 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.

11.3.1.1 Geologic Setting

The Trinity River Region is located within the southwest area of the Klamath Mountains Geomorphic Province and the northwest area of the Coast Ranges Geomorphic Province, as defined by the U.S. Geological Survey (USGS) geomorphic provinces (CGS 2002a). The Klamath Mountains Geomorphic Province covers approximately 12,000 square miles of northwestern California between the Coast Range on the west and the Cascade Range on the east and is considered to be a northern extension of the Sierra Nevada (CGS 2002a, Reclamation 1997).

The Klamath Mountains trend mostly northward. The province is primarily formed by the eastern Klamath Mountain belt, central metamorphic belt, the western Paleozoic and Triassic, and the western Jurassic belt. Rocks in this province include Paleozoic meta-sedimentary and meta-volcanic rocks, Mesozoic igneous rocks, Ordovician to Jurassic aged marine deposits in the Klamath belt, Paleozoic hornblend, mica schists and ultramafic rocks in the central metamorphic belt and slightly metamorphosed sedimentary and volcanic rocks in the western Jurassic, Paleozoic, and Triassic belt (Reclamation 1997).

The Trinity River watershed is located within the Klamath Mountain Geomorphic Province. Although the Trinity River watershed includes portions of both the Coast Ranges Province and the Klamath Mountains Province, the Trinity River riverbed is underlain by rocks of the Klamath Mountains Province (NCRWQCB et al. 2009). The Klamath Mountains Province formations generally dip towards the east and are exposed along the riverbed. Downstream of Lewiston Dam to Deadwood Creek, the area is underlain by the Eastern Klamath Terrane of the Klamath Mountains Province. The rocks in this area are primarily Copley Greenstone, metamorphosed volcanic sequence with intermediate and mafic volcanic rocks; and Bragdon formation, metamorphosed sedimentary formation with gneiss and amphibolite. Along the Trinity River between Lewiston Dam and Douglas City, outcrops of the Weaverville Formation occur. The Weaverville Formation, a series of nonmarine deposits, includes weakly consolidated mudstone, sandstone, and conglomerate of clays matrix and sparse beds of tuff. Downstream of Douglas City, the Trinity River is underlain by the Northfork and Hayfork terranes. The Northfork Terrane near Douglas City includes silicious tuff, chert, mafic volcanic rock, phyllite, and limestone sandstone and pebble conglomerate with serpentine intrusions. As the riverbed extends towards the Klamath River, the geologic formation extends into the Hayfork Terrane that consists of metamorphic and meta-volcanic rock. Terraces of sand and gravel from glacial erosion along the Trinity River flanks near Lewiston Dam contribute sediment into Trinity River.

The Trinity River flows into the Klamath River near Weitchpec. Downstream of the Weitchpec, the Klamath River flows to the Pacific Ocean through the Coast Ranges Geomorphic Province. The geology along the Klamath River in the Coast Ranges Geomorphic Province is characterized by the Eastern Belt of the Franciscan Complex and portions of the Central Belt of this complex. The Franciscan Complex consists of sandstone with some shale, chert, limestone, conglomerate, serpentine, and blueschist. The Eastern Belt is composed of schist and meta-sedimentary rocks with minor amounts of shale, chert, and conglomerate. The Central Belt is primarily composed of an argillite-matrix mélange with slabs of greenstone, serpentinte, graywacke, chert, high-grade metamorphics, and limestone.

11.3.1.2 Regional Seismicity

The areas along the Trinity River have been categorized as regions that are distant from known, active faults and generally would experience infrequent, low levels of shaking. However, infrequent earthquakes with stronger shaking could occur (CGS 2008). The closest areas to the Trinity River with known seismic active areas capable of producing an earthquake with a magnitude of 8.5 or greater are the northern San Andreas Fault Zone and the Cascadia Subduction Zone which are approximately 62 and 124 miles away, respectively (NCRWQCB et al. 2009).

The areas along the lower Klamath River downstream of the confluence with the Trinity River have a slightly higher potential for greater ground shaking than areas along the Trinity River (CGS 2008). The lower Klamath River is closer than the Trinity River to the offshore Cascadia Subduction Zone, which runs offshore of Humboldt and Del Norte counties and Oregon and Washington states. The Klamath River is approximately 30 to 40 miles from the Trinidad Fault, which extends from the area near Trinidad northwest to the coast near Trinidad State Beach. The Trinidad Fault is potentially capable of generating an earthquake with a moment magnitude of 7.3 (Humboldt County 2012).

The San Andreas Fault, under the Pacific Ocean in a northwestern direction from the Humboldt and Del Norte counties, is where the Pacific Plate moves towards the northwest relative to North America (Humboldt County 2012). The Cascadia Subduction Zone, located under the Pacific Ocean offshore from Cape Mendocino in southwest Humboldt County to Vancouver Island in British Columbia, has produced numerous earthquakes with magnitudes greater than 8. The Cascadia Subduction Zone is where the Gorda Plate and the associated Juan de Fuca Plate descend under the North American Plate.

11.3.1.3 Regional Volcanic Potential

Active centers of volcanic activity occur in the vicinity of Mount Shasta, located near the northeastern edge of the Trinity River Region. Mount Shasta is located about 45 miles north of Shasta Lake. Over the past 10,000 years, Mount Shasta erupted about once every 800 years. During the past 4,500 years, Mount Shasta erupted about once every 600 years with the most recent eruption in 1786. Lava flows, dome, and mudflows occurred during the eruptions (Reclamation 2013a).

11.3.1.4 Soil Characteristics

Soils in the southern region of the Klamath Mountain Geomorphic Province, where the Trinity River is located, are generally composed of gravelly loam with some alluvial areas with dredge tailings, river wash, and xerofluvents (NCRWQCB et al. 2009).

Soils along the lower Klamath River are generally composed of gravelly clay loam and gravelly sandy loam with sand and gravels within the alluvial deposits (DOI and DFG 2012). Alluvial deposits (river gravels) and dredge tailings provide important spawning habitat for salmon and steelhead.

11.3.1.5 Subsidence

Land subsidence is not a major occurrence in the Trinity River Region.

11.3.2 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.

11.3.2.1 Geologic Setting

The Central Valley Region is bounded by the Klamath Mountains, Cascade Range, Great Valley, Coast Ranges, and Sierra Nevada geomorphic provinces (CGS 2002a).

The Klamath Mountains Geomorphic Province was described in subsection 11.3.2, Trinity River Region. The Cascade Range Geomorphic Province consists of volcanic rocks of the Miocene to Pleistocene age. Several volcanoes within the Cascade Range Geomorphic Province and the Central Valley Region include Mount Shasta and Lassen Peak (Reclamation 2013a).

The Great Valley Geomorphic Province is an approximately 400 mile long, 50 mile wide valley that extends from the northwest to the southeast between the Sierra Nevada and Coast Ranges geomorphic provinces. The faulted and folded sediments of the Coast Range extend eastward beneath most of the Central Valley; and the igneous and metamorphic rocks of the Sierra Nevada extend westward beneath the eastern Central Valley (Reclamation 1997). The valley floor is an alluvial plain of sediments that have been deposited since the Jurassic age (CGS 2002a). Below these deposits are Cretaceous Great Valley Sequence shales and sandstones and upper Jurassic bedrock of metamorphic and igneous rocks associated in the east with the Sierra Nevada and in the west with the Coast Ranges (DWR 2007). Sediments deposited along the submarine fans within the Great Valley Geomorphic Province include mudstones, sandstones, and conglomerates from the Klamath Mountains and Sierra Nevada geomorphic provinces.

The valley floor in the Great Valley Geomorphic Province includes dissected uplands, low alluvial fans and plains, river floodplains and channels, and overflow lands and lake bottoms. The dissected uplands include consolidated and unconsolidated Tertiary and Quaternary continental deposits. The alluvial fans along the western boundary include poorly sorted fine sand, silt, and clay. The alluvial fans along the eastern boundary consist of well sorted gravel and sand along major tributaries, and poorly sorted materials along intermittent streams. River and floodplains primarily consist of coarse sands and fine silts. The lake bottoms primarily occur in the in the southern San Joaquin Valley and composed of clay layers (Reclamation 1997).

The Sierra Nevada Geomorphic Province along the eastern boundary of the Great Valley Geomorphic Province is composed of pre-Tertiary igneous and metamorphic rocks. The Sierra Nevada Geomorphic Province is an uplifted fault block nearly 400 miles long with a series of metamorphic rock on the east and deep river cuts on a gentle slope, which disappears under sediments of the Central Valley on the west. Gold-bearing veins are present in the northwest trending

Mother Lode metamorphic bedrock. The province is bordered by the Cascade Range on the north (Placer County 2007).

The Coast Ranges Geomorphic Province is composed of pre-Tertiary and Tertiary semiconsolidated to consolidated marine sedimentary rocks. The Coast Ranges Province is characterized by active uplift related to the San Andreas Fault and plate boundary system tectonics. The province extends westward toward the coastline and eastward toward the Great Valley Geomorphic Province. Rocks in this region include mafic and ultramafic rock associated with the Coast Range ophiolite, and Miocene volcanic rocks (Sonoma Volcanics) and marine and terrestrial sedimentary from the Cretaceous to the Neogene period (Reclamation et al. 2010).

11.3.2.1.1 Sacramento Valley Geological Setting

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.

Sacramento River Watershed Geological Setting

The Sacramento River flows from Shasta Lake to the Delta. The area along the Sacramento River from Shasta Lake to downstream of Red Bluff is characterized by loosely consolidated deposits of Pliocene and or Pleistocene age sandstone, shale, and gravel. Downstream of Red Bluff to the Delta, the river flows through Quaternary age alluvium, lake, playa, and terrace deposits that are unconsolidated or poorly consolidated with outcrops of resistant, cemented alluvial units such as the Modesto and Riverbank formations (CALFED 2000).

The active river channel maintains roughly constant dimensions as it migrates across the floodplain within the limits of the meander belt which is constrained only by outcrops of resistant units or artificial bank protection. Sediment loads in the tributary streams and lower reaches of the Sacramento River occur due to past and current land use practices on the tributary streams.

Feather River Watershed Geological Setting

Portions of the Feather River watershed analyzed in this EIS extend from Antelope Lake, Lake Davis, and Frenchman Lake upstream of Lake Oroville, through Lake Oroville and the Thermalito Reservoir complex, and along the Feather River to the confluence with the Sacramento River. The Yuba and Bear rivers are the major tributaries to the Feather River downstream of Thermalito Dam.

The Feather River watershed upstream of Thermalito Dam is located in the Cascade Range Geomorphic Province and the metamorphic belt of the Sierra Nevada Geomorphic Province. The lower watershed downstream of Thermalito Dam is located in the Great Valley Geomorphic Province.

West of Lake Oroville, scattered sedimentary and volcanic deposits cover the older bedrock, including (from oldest to youngest) the marine Chico formation from the upper Cretaceous; the auriferous gravels and mostly non-marine Ione formation of the Eocene Epoch; the extrusive volcanic Lovejoy basalt of the late Oligocene to early Miocene; and volcanic flows and volcaniclastic rocks of the Tuscan formation of the late Pliocene. Late Tertiary and Quaternary units in this area include alluvial terrace and fan deposits of the Plio-Pliestocene Laguna formation, the Riverbank and Modesto formations of the Pleistocene, riverbed sediments of the Holocene, and historical dredge and mine tailings from 20th century mining activities (DWR 2007).

Alluvium deposits occur in active channels of the Feather, Bear, and Yuba rivers and tributary streams. These deposits contain clay, silt, sand, gravel, cobbles, and boulders in various layers and mixtures. Historical upstream hydraulic mining significantly increased the sediment covering the lower Feather River riverbed with a thick deposit of fine clay-rich, light yellow-brown slickens (i.e., powdery matter from a quartz mill or residue from hydraulic mining). More recent floodplain deposits cover these slickens in the banks along most of the Feather River. Cobbles and coarse gravel dredge tailings constitute most of the banks, slowing the bank erosion process between the cities of Oroville and Gridley. The river is wide and shallow, with low sinuosity and a sand bed between Honcut Creek and the mouth of the Feather River.

American River Watershed Geological Setting

The Folsom Lake area is located within the Sierra Nevada and the Great Valley Geomorphic Province at the confluence of the North and South Forks of the American River. The Folsom Lake region primarily consists of rolling hills and upland plateaus between major river canyons. Three major geologic divisions within the area include a north-northwest trending belt of metamorphic rocks, granitic plutons that have intruded and obliterated some of the metamorphic belt, and deposits of volcanic ash, debris flows, and alluvial fans that are relatively flat lying. These deposits overlie older rocks (Reclamation et al. 2006).

Igneous, metamorphic, and sedimentary rock types are present within the Folsom Lake area. Major rock divisions are ultramafic intrusive rocks, metamorphic rocks, granodiorite intrusive rocks, and volcanic mud flows and alluvial deposits. Ultramafic rocks are most common on Flagstaff Mountain (Hill) on the Folsom Reservoir Peninsula located on a peninsula between the North Fork American River and South Fork American River. This rock division may contain trace amounts of serpentine minerals, chromite, minor nickel, talc, and naturally occurring asbestos (Reclamation et al. 2006).

Metamorphic rocks are found in a north-northwest trending band primarily on the eastern portions of the Folsom Lake area through most of the peninsula between the North Fork American River and South Fork American River (CGS 2010). The Metamorphic rocks are mainly composed of Copperhill Volcanics (metamorphosed basaltic breccia, pillow lava, and ash) and Ultramafic rocks, two formations that may contain trace amounts of naturally occurring asbestos (Reclamation et al. 2006).

Granodiorite intrusive rocks occur in the Rocklin Pluton on both sides of Folsom Lake extending to Lake Natoma, and the Penryn Pluton upstream of the Rocklin

Pluton. Granodiorite intrusive rocks are composed of a coarse-grained crystalline matrix with slightly more iron and magnesium-bearing minerals and less quartz than granite. Of the granodiorite, the feldspar and hornblend are less resistant than the quartz crystals and easily weathers. When weathering occurs, the remaining feldspars separate from the quartz resulting in decomposed granite (Reclamation et al. 2006).

Volcanic mud flows and alluvial deposits are present downstream of Folsom Lake in the southwest corner of two major formations, the Mehrten and Laguna Formation. The Mehrten Formation contains volcanic conglomerate, sandstone, and siltstone; all derived from andesitic sources and portions are gravels deposited by ancestral streams. The Laguna Formation, deposited predominately as debris flow on the Mehrten Formation, is a sequence of gravel, sand and silt derived from granitic sources (Reclamation et al. 2006).

The area along the American River downstream of Folsom Lake and Nimbus Reservoir is located in the Great Valley Geomorphic Province. The area includes several geomorphic land types including dissected uplands and low foothills, low alluvial fans and plains, and river floodplains and channels. The dissected uplands consist of consolidated and unconsolidated continental deposits of Tertiary and Quaternary that have been slightly folded and faulted (Reclamation 2005).

The alluvial fans and plains consist of unconsolidated continental deposits that extend from the edges of the valleys toward the valley floor (Reclamation 2005). The alluvial plains in the American River watershed include older Quaternary deposits (Sacramento County 2010). River flood plains and channels lay along the American River and smaller streams that flow into the Sacramento River south of the American River. Some floodplains are well-defined, where rivers are incised into their alluvial fans. These deposits tend to be coarse and sandy in the channels and finer and silty in the floodplains (Reclamation 2005; Sacramento County 2010).

11.3.2.1.2 Delta Geological Setting

The Delta is a northwest-trending structural basin, separating the primarily granitic rock of the Sierra Nevada from the primarily Franciscan Formation rock of the California Coast Range (CWDD 1981). The Delta is a basin within the Great Valley Geomorphic Province that is filled with a 3- to 6-mile thick layer of sediment deposited by streams originating in the Sierra Nevada, Coast Ranges, and South Cascade Range. Surficial geologic units throughout the Delta include peat and organic soils, alluvium, levee and channel deposits, dune sand deposits, older alluvium, and bedrock.

The historical delta at the confluence of the Sacramento River and San Joaquin River is referred to as the Sacramento–San Joaquin Delta, or Delta. The Delta is a flat-lying river delta that evolved at the inland margin of the San Francisco Bay Estuary as two overlapping and coalescing geomorphic units: the Sacramento River Delta to the north and the San Joaquin River Delta to the south. During large river-flood events, silts and sands were deposited adjacent to the river channel, formed as a tidal marsh with few natural levees, and was dominated by tidal flows, allowing for landward accumulation of sediment behind the bedrock barrier at the Carquinez Strait. The sediment formed marshlands, which consisted of approximately 100 islands that were surrounded by hundreds of miles of channels. Generally, mineral soils formed near the channels during flood conditions and organic soils formed on marsh island interiors as plant residues accumulated faster than they could decompose (Weir 1949).

In the past, because the San Joaquin River Delta had less well-defined levees than under current conditions, sediments were deposited more uniformly across the floodplain during high water, creating an extensive tule marsh with many small, branching tributary channels. Because of the differential amounts of inorganic sediment supply, the peat of the San Joaquin River Delta grades northward into peaty mud and mud toward the natural levees and flood basins of the Sacramento River Delta (Atwater et al. 1980).

The Delta has experienced several cycles of deposition, nondeposition, and erosion that have resulted in the thick accumulation of poorly consolidated to unconsolidated sediments overlying the Cretaceous and Tertiary formations since late Quaternary time. Shlemon and Begg (1975) calculated that the peat and organic soils in the Delta began to form about 11,000 years ago during an episode of sea level rise. Tule marshes established on peat and organic soils in many portions of the Delta. Additional peat and other organic soils formed from repeated inundation and accumulation of sediment of the tules and other marsh vegetation.

11.3.2.1.3 Suisun Marsh Geological Setting

The Suisun Marsh area is located within the Coast Ranges Geomorphic Province. The Suisun Marsh is bounded by the steep Coast Range on the west and by the rolling Montezuma Hills on the east. The Montezuma Hills consist of uplifted Pleistocene sedimentary layers with active Holocene age alluvium in stream drainages that divide the uplift. Low-lying flat areas of the marshland are covered by Holocene age Bay Mud deposits. The topographically higher central portions of Grizzly Island in the marshlands north of the Suisun Bay are formed by the Potrero Hills. These hills primarily consist of folded and faulted Eocene marine sedimentary rocks and late Pleistocene alluvial fan deposits (Reclamation et al. 2010).

11.3.2.1.4 San Joaquin Valley Geological Setting

The San Joaquin Valley is located within the southern half of the Great Valley Geomorphic Province. The 250-mile-long and 50-to-60-mile-wide valley lies between the Coast Ranges on the west, the Sierra Nevada on the east, and extends northwestward to the Delta near the City of Stockton. The San Joaquin Valley is the southern portion of a large, northwest-to-southeast-trending asymmetric trough filled with up to six vertical miles of Jurassic to Holocene age sediments. The trough is primarily made up of Tertiary and Quaternary continental rocks, and deposits, which become separated by lacustrine, marsh, and floodplain deposits of varying thicknesses. The continental deposits, which include the Mehrten, Kern River, Laguna, San Joaquin, Tulare, Tehama, Turlock, Riverbank, and Modesto formations, form the San Joaquin Valley aquifer (Ferriz 2001, Reclamation et al. 2011, Reclamation 2009).

Dissected uplands, low alluvial fans and plains, river floodplains and channels, and overflow lands and lake bottoms are the several geomorphic land types within the San Joaquin Valley. Dissected uplands consist of slightly folded and faulted, consolidated and unconsolidated, Tertiary and Quaternary age continental deposits. The alluvial fans and plains, which cover most of the valley floor, consist of unconsolidated continental deposits that extend from the edges of the valleys toward the valley floor. In general, alluvial sediments of the western and southern parts of the San Joaquin Valley tend to have lower permeability than deposits on the eastern side. River floodplains and channels lie along the major rivers and are well-defined where rivers incise their alluvial fans. Typically, these deposits are coarse and sandy in the channels and finer and silty in the floodplains (Reclamation et al. 2011).

Lake bottoms of overflow lands in the San Joaquin Valley include historic beds of Tulare Lake, Buena Vista Lake, and Kern Lake as well as other less defined areas in the valley trough. Near the valley trough, fluvial deposits of the east and west sides grade into fine-grained deposits. The largest lake deposits in the Central Valley are found beneath the Tulare Lake bed where up to 3,600 feet of lacustrine and marsh deposits form the Tulare Formation. This formation is composed of widespread clay layers, the most extensive being the Cocoran Clay member which also is found in the western and southern portions of the San Joaquin Valley. The Cocoran Clay member is a confining layer that separates the upper semi-confined to unconfined aquifer from the lower confined aquifer (Reclamation 1997).

The valley floor and foothills portions of the San Joaquin Valley and San Joaquin River area, and the Stanislaus River watershed could be affected by CVP and SWP operations. The Stanislaus River watershed originates in the Sierra Nevada Geomorphic Province, including the area with New Melones Reservoir, and extends into the Great Valley Geomorphic Province. New Melones Reservoir is oriented along a northwest trend that is produced by the Foothill Metamorphic Belt in the Sierra Nevada Geomorphic Province (Reclamation 2010). The area is underlain by Cenozoic sedimentary rocks which dip towards the southwest and overlies the Cretaceous sedimentary rocks of the Great Valley sequence and older metamorphic basement rocks along the edges of the Sierra Nevada. Tertiary sedimentary formations were deposited along the Stanislaus River from an area east of Knights Ferry to Oakdale (CGS 1977). The oldest Tertiary geologic unit, Eocene Ione Formation, primarily consists of quartz, sandstone, and interbedded kaolinitic clays with a maximum thickness of about 200 feet near Knights Ferry. The Oligocene-Miocene Valley Springs Formation of rhyolitic ash, sandy clay, and gravel deposits overlay the Ione Formation. Andestic flows, lahars, and volcanic sediments of the Mehrten Formation were deposited by volcanism, especially from Table Mountain (CGS 1977; Reclamation 2010). Three major alluvial fan deposits occurred along the Stanislaus River after deposition of the

Mehrten Formation, including the Turlock Lake Formation (between Orange Blossom Road and Oakdale) composed of fine sand and silt with some clay, sand, and gravel; Riverbank Formation (between Oakdale and Riverbank) composed of silt and clay; and Modesto Formation (between Riverbank and the confluence with the San Joaquin River) composed of sand, silt, clay, and gravel.

11.3.2.2 Regional Seismicity

Most of the areas in the Central Valley Region have been categorized as regions that are distant from known, active faults and generally would experience infrequent, low levels of shaking. However, infrequent earthquakes with stronger shaking could occur (CGS 2008). Areas within and adjacent to the Delta Region and along Interstate 5 in the San Joaquin Valley have a higher potential for stronger ground shaking due to their close proximity to the San Andreas Fault Zone.

The San Andreas Fault Zone is located to the west of the Central Valley Region along a 150-mile northwest-trending fault zone (Reclamation 2013a). The fault zone extends from the Gulf of California to Point Reyes where the fault extends under the Pacific Ocean (CGS 2006). The fault zone is the largest active fault in California (Reclamation 2005d).

In the Sacramento Valley, the major fault zones include the Battle Creek Fault Zone located to the east of the Sacramento River, Corning Fault that extends from Red Bluff to Artois parallel to the Corning Canal, Dunnigan Hills Fault located west of Interstate 5 near Dunnigan, Cleveland Fault located near Oroville, and Great Valley Fault system along the west side of the Sacramento Valley (Reclamation 2005a, Reclamation 2013a).

The Delta and Suisun Marsh are located in proximity to several major fault systems, including the San Andreas, Hayward-Rodgers Creek, Calaveras, Concord-Green Valley, and Greenville faults (DWR et al. 2013a). There are also many named and unnamed regional faults in the vicinity. The majority of seismic sources underlying the Delta and Suisun Marsh are “blind” thrusts that are not expected to rupture to the ground surface during an earthquake. The known blind thrusts in the Delta and Suisun Marsh area include the Midland, Montezuma Hills, Thornton Arch, Western Tracy, Midland, and Vernalis faults. Blind thrust faults with discernible geomorphic expression/trace located at the surface occur near the southwestern boundary of the Delta include Black Butte and Midway faults. Two surface crustal fault zones (e.g., areas with localized deformation of geologic features near the surface) are located within the Suisun Marsh, including the Pittsburgh-Kirby Hills fault which occurs along an alignment between Fairfield and Pittsburg, and Concord-Green Valley fault which crosses the western portion of the Suisun Marsh. The Cordelia fault is a surface crustal fault zone that occurs near the western boundary of the Suisun Marsh. Since 1800, no earthquakes with a magnitude greater than 5.0 have been recorded in the Delta or Suisun Marsh.

In the San Joaquin Valley, the eastern foothills are characterized by strike-slip faults that occur because the rock underlying the valley sediment is slowly moving downward relative to the Sierra Nevada Block to the east. An example of this type of faulting is the Kings Canyon lineament which crosses the valley north of Chowchilla and continues nearly to Death Valley in southeastern California (Reclamation et al. 2011). Uplift and tilting of the Sierra Nevada block towards the west and tilting of the Coast Ranges block to the east appear to be causing gradual downward movement of the valley basement rock, in addition to subsidence caused by aquifer compaction and soil compaction discussed below. The San Joaquin Valley is bounded by the Stockton Fault of the Stockton Arch on the north and the Bakersfield Arch on the south. Most of the fault zones in the San Joaquin Valley do not appear to be active. However, numerous faults may not be known until future seismic events, such as the Nunez reverse fault which was not known until the 1983 Coalinga earthquake. In areas adjacent to the San Joaquin Valley, the dominant active fault structure is the Great Valley blind thrust associated with San Andreas Fault. Other active faults occur along the western boundary of the San Joaquin Valley, including the Hayward, Concord-Green Valley, Coast Ranges-Sierra Block boundary thrusts, Mount Diablo, Greenville, Ortigalita, Rinconada, and Hosgri faults (Reclamation 2005d).

11.3.2.3 Regional Volcanic Potential

Active centers of volcanic activity occur in the vicinity of Mount Shasta and Lassen Peak in the Central Valley Region. Mount Shasta is located about 45 miles north of Shasta Lake. Over the past 10,000 years, Mount Shasta erupted about once every 800 years. During the past 4,500 years, Mount Shasta erupted about once every 600 years with the last eruption in 1786. Lava flows, domes, and mudflows occurred during the eruptions (Reclamation 2013a).

Lassen Peak, located about 50 miles southeast of Shasta Lake, is a cluster of dacitic domes and vents that have formed during eruptions over the past 250,000 years. The last eruptions were relatively small and occurred between 1914 and 1917. The most recent large eruption occurred about 1,100 years ago. Large eruptions appear to occur about once every 10,000 years (USGS 2000a).

11.3.2.4 Soil Characteristics

The Central Valley Region includes the Sacramento Valley, Delta, Suisun Marsh, and San Joaquin Valley. The soil characteristics are similar in many aspects in the Sacramento and San Joaquin valleys; therefore, the descriptions are combined in the following sections.

11.3.2.4.1 Sacramento Valley and San Joaquin Valley Soil Characteristics

The Sacramento Valley and San Joaquin Valley contain terrace land and upland soils along the foothills; and alluvial, Aeolian, clayey, and saline/alkaline soils in various locations along the valley floors (CALFED 2000, Reclamation 1997).

Foothills soils, located on well-drained, hilly-to-mountainous terrain along the east side of the Central Valley, form through in-place weathering of the underlying rock. Soils in the northern Sacramento Valley near Shasta Lake are different than soils along other foothills in the Sacramento and San Joaquin valleys. The soils near Shasta Lake are related to the geologic formations of the Klamath Mountains, Cascade Ranges, and Sierra Nevada geomorphic provinces.

These soils are formed from weathered metavolcanic and metasedimentary rocks and from intrusions of granitic rocks, serpentine, and basalt. These soils are generally shallow with numerous areas of gravels, cobbles, and stones; therefore, they do not have high water-holding capacity or support topsoil productivity for vegetation (Reclamation 2013a). Soils derived from in-place weathering of granitic rock, referred to as decomposed granite, are coarse-grained, quartz-rich and erodible.

Upland soils along other foothills in the Sacramento and San Joaquin valleys are formed from the Sierra Nevada and Coast ranges geomorphic provinces. Along the western boundary of the Central Valley, the soils primarily are formed from sedimentary rocks. Along the eastern boundary of the Central Valley, the soils primarily are formed from igneous and metamorphic rock. The soils include serpentine soils (which include magnesium, nickel, cobalt, chromium, iron, and asbestos); sedimentary sandstones; shales; conglomerates; and sandy loam, loam, and clay loam soils above bedrock (Reclamation 1997, Reclamation et al. 2011, Reclamation 2013a, DWR 2007). Erosion occurs in the upland soils around reservoirs and rivers especially downgradient of urban development where paving increases the peak flow, volume, and velocity of precipitation runoff (GCI 2003).

Along the western boundary of the Sacramento Valley and the southeastern boundary of the San Joaquin Valley, the terrace lands include brownish loam, silt loam, and/or clayey loam soils. The soils are generally loamy along the Sacramento Valley terraces, and more clayey along the San Joaquin Valley terraces. Along the eastern boundaries of Sacramento and San Joaquin valleys, the terraces are primarily red silica-iron cemented hardpan and clays, sometimes with calcium carbonate (also known as “lime”) (DWR 2007, Reclamation 1997, Reclamation 2005b, Reclamation 2012).

Surface soils of the Central Valley include alluvial and Aeolian soils. The alluvial soils include calcic brown and noncalcic brown alluvial soils on deep alluvial fans and floodplains. The calcic brown soil is primarily made of calcium carbonate and alkaline (also known as “calcerous” soils). The noncalcic brown soils do not contain calcium carbonate and are either slightly acidic or neutral in chemical properties. In the western San Joaquin Valley, light colored calcerous soils occur with less organic matter than the brown soils (Reclamation 1997).

Basin soils occur in the San Joaquin Valley and portions of the Delta. These soils include organic soils, imperfectly drained soils, and saline alkali soils. The organic soils are typically dark, acidic, high in organic matter, and generally include peat. The organic soils occur in the Delta, as discussed below, and along the lower San Joaquin River adjacent to the Delta. The poorly drained soils contain dark clays and occur in areas with high groundwater in the San Joaquin Valley trough and as lake bed deposits (Reclamation et al. 2011). One of the most substantial stratigraphic features of the San Joaquin Valley and a major aquitard is the Corcoran Clay, located in the western and central valley (Galloway et al. 1999). The western boundary of the Corcoran Clay is generally located along the Delta-Mendota Canal and California Aqueduct (as described in Chapter 5, Surface Water Resources and Water Supply). The Corcoran Clay generally extends from Mendota Pool area through the center of the valley to the Tehachapi Mountains. The depth to the Corcoran Clay varies from 160 feet under the Tulare Lake bed to less than a foot near the western edge of the Central Valley. The Corcoran Clay compromised of numerous aquitards and coarser interbeds.

Selenium salts and other salts occur naturally in the western and central San Joaquin Valley soils that are derived from marine sedimentary rocks of the Coast Ranges. Salts are leached from the soils by applied pre-irrigation and irrigation water and collected by a series of drains. The drains also reduce high groundwater elevations in areas with shallow clay soils. Reclamation and other agencies are implementing programs to reduce salinity issues in the San Joaquin Valley that will convey and dispose of drainage water in a manner that would protect the surface water and groundwater resources (Reclamation et al. 2011). As described in Chapter 12, Agricultural Resources, many portions of the western and central San Joaquin Valley are no longer supporting irrigated crops or are experiencing low crop yields due to the saline soils.

Soils in the eastern San Joaquin Valley come from the Sierra Nevada and contain low levels of salt and selenium. Most soils in the western and southern San Joaquin Valley are formed from Coast Range marine sediments, and contain higher concentrations of salts as well as selenium and molybdenum. Soluble selenium moves from soils into drainage water and groundwater, especially during agricultural operations to leach salts from the soils. As described in Chapter 3, Description of Alternatives, Reclamation and other agencies are implementing programs to reduce the discharge of selenium from the San Joaquin Valley into receiving waters (Reclamation 2005d, Reclamation et al. 2011, Reclamation 2009). Additional information related to concerns with salinity and selenium in the San Joaquin Valley is presented in Chapter 6, Surface Water Quality, and Chapter 12, Agricultural Resources.

Soil wind erosion is related to soil erodibility, wind speeds, soil moisture, surface roughness, and vegetative cover. Aeolian soils are more susceptible to wind erosion than alluvial soils. Non-irrigated soils that have been disturbed by cultivation or other activities throughout the Central Valley are more susceptible to wind erosion and subsequent blowing dust than soils with more soil moisture. Dust from eroding soils can create hazards due to soil composition (such as naturally-occurring asbestos), allergic reactions to dust, adverse impacts to plants due to dust, and increased risk of valley fever (as discussed in Chapter 18, Public Health) (Reclamation 2005d).

11.3.2.4.2 Delta Soil Characteristics

Soils in the Delta include organic and/or highly organic mineral soils; deltaic soils along the Sacramento and San Joaquin rivers; basin rim soils; floodplain and stream terrace soils; valley alluvial and low terrace soils; and upland and high terrace soils (Reclamation 1997). Basin, deltaic, and organic soils occupy the lowest elevation ranges and are often protected by levees. In many areas of the western Delta, the soils contain substantial organic matter and are classified as peat or muck.

Basin rim soils are found along the eastern edges (rims) of the Delta, and are generally moderately deep or deep mineral soils that are poorly drained to well-drained and have fine textures in surface horizons. Some areas contain soils with a hardpan layer in the subsurface (SCS 1992, 1993). Floodplain and stream terrace soils are mineral soils adjacent to the Sacramento and San Joaquin rivers and other major tributaries. These soils are typically deep and stratified, with relatively poor drainage and fine textures. Valley fill, alluvial fan, and low terrace soils are typically very deep with variable texture and ability to transmit water ranging from somewhat poorly drained fine sandy loams and silty clay loams to well-drained silt loams and silty clay loams. Upland and high terrace soils are generally well-drained ranging in texture from loams to clays and are primarily formed in material weathered from sandstone, shale, and siltstone, and can occur on dissected terraces or on mountainous uplands.

Soils within the Yolo Bypass area range from clays to silty clay loams and alluvial soils (CALFED 2001, DFG et al. 2008). The higher clay content soils occur in the western portion of the basin north of Interstate 80 and in the eastern portion of the basin south of Interstate 80. The silty clay loams and alluvial soils occur in the western portion of the basin south of Interstate 80, including soils within the Yolo Bypass Wildlife Area.

Soil erosion by rainfall or flowing water occurs when raindrops detach soil particles or when flowing water erodes and transports soil material. Sandy alluvial soils, silty lacustrine soil, and highly organic soil are erodible. Organic soil (peat) in the Delta is also susceptible to wind erosion (deflation). Clay soils are erosion resistant.

11.3.2.4.3 Suisun Marsh Soil Characteristics

Soil within the Suisun Bay include the Joice muck, Suisun peaty muck, and Tamba mucky clay; Reyes silty clay; and Valdez loam (SCS 1977a, Reclamation et al. 2010). The Joice muck generally is poorly drained organic soils in saline water areas interspersed with fine-grain sediment. Suisun peaty muck is formed from dark colored organic soils and plant materials with high permeability. These soils are generally located in areas with shallow surface water and groundwater; therefore, surface water tends to accumulate on the surface. Tamba mucky clay also are poorly drained organic soils formed from alluvial soils and plant materials that overlays mucky clays. Reyes silty clays are poorly drained soils formed from alluvium. The upper layers of the silty clays are acidic and saline. The lower layers are alkaline that become acidic when exposed to air, especially under wetting-drying conditions in tidal areas. Valdez loam soils are poorly drained soils formed on alluvial fans.

Suisun Marsh soils have a low susceptibility to water and wind erosion (SCS 1977a, Reclamation et al. 2010).

11.3.2.5 Subsidence

Land subsidence occurs for different reasons throughout the Central Valley as described in the following sections.

11.3.2.5.1 Sacramento and San Joaquin Valley Subsidence

Land subsidence in the Sacramento Valley primarily occurs due to aquifer-system compaction as groundwater elevations decline; weathering of underlying of some-types of bedrock, such as limestone; decomposition of organic matter; and natural compaction of soils (Reclamation 2013a). Historic subsidence of the Sacramento Valley has been far less than that observed in the San Joaquin Valley. For example, the range of recent historic subsidence in the Sacramento Valley is generally less than 10 feet. Historical subsidence in the San Joaquin Valley has caused changes in land elevations of more than 30 feet.

In the 1970s, land subsidence exceeded 1 foot near Zamora; however, additional subsidence has not been reported since 1973 (Reclamation 2013a). Subsidence has been reported of two feet near Davis and three to four feet over the last several decades in the areas north of Woodland and east of Davis and Woodland (Davis 2007).

San Joaquin Valley subsidence primarily occurs when groundwater elevations decline which reduces water pressure in the soils and results in compressed clay lenses and subsided land elevations. Other factors that may influence the rate of subsidence in the San Joaquin Valley is the Sierran uplift, sediment loading and compressional down-warping or thrust loading from the Coast Ranges, and near surface compaction (Reclamation et al. 2011). Some of the first reports of land subsidence in the San Joaquin Valley occurred in 1935 in the area near Delano (Galloway et al. 1999). By the late 1960s, San Joaquin Valley subsidence had occurred over 5,212 square miles, or almost 50 percent of the San Joaquin Valley (Reclamation 2005d). During that period, some areas subsided over 33 vertical feet since the late 1880s. The rate of subsidence reduced initially following implementation of CVP and SWP water supplies in the San Joaquin Valley during the 1970s and 1980s. The rate of subsidence for the next twenty years appeared to continue at a rate of 0.008 to 0.016 inches/year in recent years (Reclamation et al. 2011). However, the amount of water available for irrigation from the CVP and SWP has declined more than 20 to 30 percent since the early 1980s due to hydrologic, regulatory, and operational concerns, as described in Chapter 1, Introduction. Due to the reduction in the availability of CVP and SWP water supplies, many water users have increased groundwater withdrawal. A recent study by the USGS of subsidence along the CVP Delta-Mendota Canal (USGS 2013b) reported that in areas where groundwater levels fluctuated consistently on a seasonal basis but were stable on a long-term basis, the land elevations also were relatively stable. Subsidence occurred in portions of the San Joaquin Valley where groundwater elevations below the Corcoran clay and in the shallow groundwater declined on a long-term basis between 2003 and 2010. The highest subsidence rates occurred along the Delta Mendota Canal between Merced and Mendota with subsidence of 0.8 inches to 21 inches between 2003 and 2010.

Shallow subsidence, or hydrocompaction, occurs when low density, relatively dry, fine-grained sediments soften and collapse upon wetting. Historically, hydrocompaction has been most common along the western margin of the San Joaquin Valley (Reclamation 2005c). In the southern San Joaquin Valley, extraction of oil also can result in compaction. Changes in elevation, both subsidence and uplift, occurred near Coalinga following the 1983 Coalinga earthquake with uplift up to 1.6 feet and subsidence of 2 inches.

11.3.2.5.2 Delta and Suisun Marsh Subsidence

Land subsidence on the islands in the central and western Delta and Suisun Marsh may be caused by the elimination of tidal inundation that formed the islands through sediment deposition and transport, and the oxidation and decay of plant materials that would compact to form soils. Following construction of levees, subsidence initially occurred through the mechanical settling of peat as the soil dried; and then, the dried peat and other soils shrunk (Reclamation et al. 2013, Drexler et al. 2009). Agricultural burning of peat (which has been discontinued), wind erosion, oxidation, and leaching of organic material. The rate of subsidence has declined from a maximum of 1.1 to 4.6 inches/year in the 1950s to less than 0.2 to 1.2 inches/year in the western Delta (Drexler et al. 2009, Rojstaczer et al. 1991). Many of the islands in the western and central Delta have subsided to elevations that are 10 to nearly 55 feet below sea level (USGS 2000b, Deverel and Leighton 2010).

Recently, the California Department of Water Resources has implemented several projects to reverse subsidence. The 274-acre Mayberry Farms Duck Club Subsidence Reversal Project on Sherman Island includes creation of emergent wetlands ponds and channels through excavation of peat soils, improving of water movement, and waterfowl habitat. The facility was constructed in 2010 and is being monitored to determine the effectiveness of subsidence reversal, methyl mercury management, and carbon sequestration (DWR 2013). The Department of Water Resources and USGS implemented wetlands restoration for about 15 acres on Twitchell Island in 1997 (DWR et al. 2013b) to encourage tule and cattail growth. After the growing season, the decomposed plant material accumulates and increases the land elevation. Since 1997, elevations have increased at a rate of 1.3 to 2.2 inches/year.

11.3.3 San Francisco Bay Area Region

The San Francisco Bay Area Region includes portions of Contra Costa, Alameda, Santa Clara, San Benito, and Napa counties that are within the CVP and SWP service areas. Portions of Napa County are within the SWP service area that use water diverted from Barker Slough in the Sacramento River watershed for portions of Solano and Napa counties. Solano County was discussed under the Delta area of the Central Valley Region. Napa County is described under the San Francisco Bay Area Region.

11.3.3.1 Geologic Setting

The San Francisco Bay Area Region primarily is located within the Coast Ranges Geomorphic Province. Eastern Contra Costa and Alameda counties are located in the Great Valley Geomorphic Province. The Coast Ranges and Great Valley geomorphic provinces were described in Section 11.3.2, Central Valley Region. San Francisco Bay is a structural trough formed as a gap in the Coast Range down-dropped to allow the Sacramento, San Joaquin, Napa, Guadalupe, and Coyote Rivers to flow into the Pacific Ocean. When the polar ice caps melted 10,000 to 25,000 years ago the ocean filled the inland valleys of the trough and formed San Francisco Bay, San Pablo Bay, and Suisun Bay (CALFED 2000). Initially, alluvial sands, silts, and clays filled the bays to form Bay Mud along the shoreline areas. Sedimentation patterns have changed over the past 150 years due to development of upstream areas of the watersheds which changed sedimentation and hydraulic flow patterns, hydraulic mining, and formation of levees and dams.

The San Francisco Bay Area is formed from the Salinian block located west of the San Andreas Fault; Mesozoic Franciscan complex located between the San Andreas and Hayward faults; and the Great Valley sequence located to the east of Hayward Fault (WTA 2003). The Salinian block generally is composed of granitic plutonic rocks probably from the Sierra Nevada Batholith that was displaced due to movement along the San Andreas Fault. The Franciscan complex includes deep marine sandstone and shale formed from oceanic crust with chert and limestone. The Great Valley sequence primarily includes marine sedimentary rocks.

11.3.3.2 Regional Seismicity

Large earthquakes have occurred in the San Francisco Bay Area Region along the San Andreas, Hayward, Calaveras, Greenville, Antioch, Concord-Green Valley, Midway, Midland, and Black Butte fault zones over the past 10,000 years. The San Francisco earthquake of 1906 took place as the result of movement along the San Andreas Fault. The San Andreas Fault remains active, as does the Hayward Fault, based on evidence of slippage along both (CALFED 2000).

11.3.3.3 Soil Characteristics

The San Francisco Bay Area Region soils include basin floor/basin rim, floodplain/valley land, terrace, foothill, and mountain soils (CALFED 2000). Basin floor/basin rim soils are organic-rich saline soils and poorly drained clays, clay loams, silty clay loams, and muck along the San Francisco Bay shoreline (SCS 1977b, 1981a; CALFED 2000). Well-drained sands and loamy sands and poorly-drained silty loams, clay loams, and clays occur on gently sloping alluvial fans of the San Francisco Bay Area Region that surround the floodplain and valley lands. Drained loams, silty loams, silty clay loams, and clay loams interbedded with sedimentary rock and some igneous rock occur in the foothills. Terrace loams are located along the southeastern edge of the San Francisco Bay Area Region above the valley land.

11.3.3.4 Subsidence

Subsidence in the San Francisco Bay Area Region primarily occurs in the Santa Clara Valley of Santa Clara County. The Santa Clara Valley is characterized by a groundwater aquifer with layers of non-consolidated porous soils interspersed with clay lenses. Historically, when the groundwater aquifer was in overdraft, the water pressure in the soils declined which resulted in compressed clay lenses and subsided land elevations. Between 1940 and 1970, soils near San Francisco Bay declined to elevations below sea level (SCVWD 2000). Under these conditions, salt water intrusion and tidal flooding occurred in the tributary streams of Guadalupe River and Coyote Creek. As of 2000, the land elevation in downtown San Jose subsided 13 feet since 1915. In 1951, water deliveries from San Francisco Water Department were initiated (Ingebritsen et al. 1999). In 1965, SWP deliveries were initiated in Santa Clara County. CVP water deliveries were initiated in 1987. The CVP and SWP water supplies are used to reduce groundwater withdrawals when groundwater elevations are low to allow natural recharge from local surface waters. The CVP and SWP also are used to directly recharge the groundwater through spreading basins in Santa Clara Valley.

11.3.3.5 Central Coast and Southern California Regions

The Central Coast Region includes portions of San Luis Obispo and Santa Barbara counties served by the SWP. The Southern California Region includes portions of Ventura, Los Angeles, Orange, San Diego, Riverside, and San Bernardino counties served by the SWP.

As described in Chapter 4, Approach to Environmental Analysis, the Southern California Region includes areas affected by operations of the SWP, including the Coachella Valley in Riverside County. The Coachella Valley Water District receives water under a SWP entitlement contract; however, SWP water cannot be conveyed directly to the Coachella Valley due to lack of conveyance facilities. Therefore, Coachella Valley Water District receives water from the Colorado River through an exchange agreement with the Metropolitan Water District of Southern California, as described in Chapter 5, Surface Water Resources and Water Supplies. The Imperial Valley, located to the southeast of the Southern California Region, receives irrigation water from the Colorado River through Reclamation canals; and does not use CVP or SWP water.

11.3.3.6 Geologic Setting

The Central Coast and Southern California Regions are located in the Coast Ranges, Transverse Ranges, Peninsular Ranges, Colorado Desert, and Mojave Desert geomorphic provinces (CGS 2002a).

The Central Coast Region includes portions of San Luis Obispo and Santa Barbara counties that use SWP water supplies. These areas are located within the Coast Ranges and Transverse Ranges geomorphic provinces. The Coast Ranges Geomorphic Province was described in Section 11.3.2, Central Valley Region. The Transverse Ranges Geomorphic Province consists of deeply folded and faulted sedimentary rocks (CGS 2002a, SBCAG 2013). Bedrock along the stream channels, coastal terraces, and coastal lowlands is overlain by alluvial and terrace deposits; and, in some area, ancient sand dunes. The geomorphic province is being uplifted at the southern border along San Andreas Fault and compressed at the northern border along the Coast Ranges Geomorphic Province. Therefore, the geologic structure of the ridges and valleys are oriented along an east-west orientation, or in a “transverse” orientation, as compared to the north-south orientation of the Coast Range.

The Southern California Region includes portions of Ventura, Los Angeles, Orange, San Diego, Riverside, and San Bernardino counties that use SWP water supplies. These areas are located within the Transverse Ranges, Peninsular Ranges, Mojave Desert, and Colorado Desert geomorphic provinces. The Transverse Ranges Geomorphic Province includes Ventura County and portions of Los Angeles, San Bernardino, and Riverside counties. The Colorado Desert Geomorphic Province is also known as the Salton Trough where the Pacific and North American plants are separating.

The Peninsular Ranges Geomorphic Province is composed of granitic rock with metamorphic rocks (CGS 2002a, SCAG 2011, San Diego County 2011). The geologic structure is similar to the geology of the Sierra Nevada Geomorphic Province. The faulting of this geomorphic province has resulted in northwest trending valleys and ridges that extend into the Pacific Ocean to form the Santa Catalina, Santa Barbara, San Clemente, and San Nicolas islands. The Peninsular Ranges Geomorphic Province includes Orange County and portions of southern Los Angeles County, western San Diego County, northwestern San Bernardino County, and northern Riverside County (including the northern portion of the Coachella Valley).

The Mojave Desert Geomorphic Province is located between the Garlock Fault along the southern boundary of the Sierra Nevada Geomorphic Province and the San Andreas Fault (CGS 2002a, SCAG 2011, RCIP 2000). This geomorphic province includes extensive alluvial basins with non-marine sediments from the surrounding mountains and foothills; and many isolated ephemeral lakebeds (also known as “playas”) occur within this region with tributary streams from isolated mountain ranges. The Mojave Desert Geomorphic Province includes portions of Kern, Los Angeles, Riverside, and San Bernardino counties.

The Colorado Desert Geomorphic Province, or Salton Trough, is characterized by a geographically-depressed desert that extends northward from the Gulf of California (located at the mouth of the Colorado River) towards the Mojave Desert Geomorphic Province where the Pacific and North American plants are separating (CGS 2002a, SCAG 2011, RCIP 2000, San Diego County 2011). Large portions of this geomorphic province were formed by the inundation of the ancient Lake Cahuilla and are filled with sediments several miles thick from the historic Colorado River overflows and erosion of the Peninsular Ranges uplands. The Salton Trough is separated from the Gulf of California by a large ridge of sediment. The Salton Sea occurs within the trough along an ancient playa. The Colorado Desert Geomorphic Province includes portions of Riverside County in the Coachella Valley; and portions of San Diego and Imperial counties that are located outside of the study area.

11.3.3.7 Regional Seismicity

Most of the areas in the Central Coast and Southern California regions are characterized by active faults that are capable of producing major earthquakes with substantial ground displacement. The San Andreas Fault Zone extends from the Gulf of California and extends in a northwest direction throughout the Central Coast and Southern California regions (CGS 2006).

Within portions of San Luis Obispo County that use SWP water supplies, the Nacimiento Fault also can result in major seismic events (CGS 2006, San Luis Obispo County 2010a).

The northern portions of Santa Barbara County that use SWP water supplies include Lion’s Head Fault along the Pacific Ocean shoreline to the southwest of Santa Maria and along the northern boundary of Vandenberg Air Force Base (CGS 2006, SBCAG 2013). The Big Pine Fault may extend into the Vandenberg Air Force Base area. Areas near the mouth of the Santa Ynez River and Point Arguello could be affected by Lompoc Terrace Fault and Santa Ynez-Pacifico Fault Zone. The Santa Ynez Fault extends across this county and could affect communities near Santa Ynez. Along the southern coast of Santa Barbara County from Goleta to Carpinteria, the area includes many active faults, including More Ranch, Mission Ridge, Arroyo Parida, and Red Mountain faults; and potentially active faults, including Goleta, Mesa-Rincon, and Carpinteria faults.

Portions of Ventura County that use SWP water supplies are located in the southern portion of the county adjacent to Los Angeles County. Major faults in this area include the Oak Ridge Fault that extends into the Oxnard Plain along the south side of the Santa Clara River Valley and may extend into San Fernando Valley in Los Angeles County; Bailey Fault that extends from the Pacific Ocean to the Camarillo Fault; Simi-Santa Rosa, Camarillo, and Springville faults in Simi and Tierra Rejada valleys and near Camarillo; Sycamore Canyon and Boney Mountain faults that extend from the Pacific Ocean towards Thousand Oaks (CGS 2006, Ventura County 2011).

Los Angeles County major fault zones include Northridge Hills, San Gabriel, San Fernando, Verduga, Sierra Madre, Raymond, Hollywood, Santa Monica, and Malibu Coast fault zones; Elysian Park Fold and Thrust Belt in Los Angeles County; and Newport, Inglewood, Whittier, and Palos Verdes fault zones that extend into Los Angeles and Orange counties (CGS 2006, Los Angeles 2005). Recent major seismic events that have occurred in Southern California along faults in Los Angeles include the 1971 San Fernando, 1987 Whittier Narrows, 1991 Sierra Madre, and 1994 Northridge earthquakes.

Riverside and San Bernardino counties are characterized by the San Andreas Fault Zone that extends from the eastern boundaries of these counties and crosses to the western side of San Bernardino County (CGS 2006, RCIP 2000, Riverside County 2000, SCAG 2011, DWR 2009). The San Jacinto Fault Zone also extends through the center of Riverside County and along the western side of San Bernardino County. The Elsinore Fault Zone extends along the western sides of both counties. In San Bernardino County, the Cucamonga Fault extends into

Los Angeles County where it intersects with the Sierra Madre and Raymond faults. The Garlock and Lockhart fault zones extend into both San Bernardino and Kern counties. San Bernardino County also includes several other major fault zones, including North Frontal, and Helendale faults.

Portions of San Diego County that use SWP water supplies include the Rose Canyon Fault Zone located along the Pacific Ocean shoreline and extends into the City of San Diego (San Diego County 2011).

11.3.3.8 Soil Characteristics

In the Central Coast Region, areas within San Luis Obispo and Santa Barbara counties that use SWP water supplies are located within coastal valleys or along the Pacific Ocean shoreline. In San Luis Obispo County, Morro Bay, Pismo Beach, and Oceano areas are located along the coast with soils that range from sands and loamy sands in areas near the shoreline to shaly loams, clay loams, and clays in the terraces and foothills located along the eastern boundaries of these communities (SBCAG 2010b, NRCS 2014a, NRCS 2014b). In Santa Barbara County, the Santa Maria, Vandenberg Air Force Base, Santa Ynez, Goleta, Santa Barbara, and Carpinteria areas are located in alluvial plains, along stream channels with alluvium deposits, along the shoreline, or along marine terrace deposits above the Pacific Ocean. The soils range from sands, sandy loams, loams, shaly loams, and clay loams in the alluvial soils and along the shoreline. The terrace deposits include silty clays, clay loams, and clays (NRCS 2014c, NRCS 2014d, NRCS 2014e, SCS 1972, SCS 1981b).

Southern California Region soils include gravelly loams and gravelly sands, sands, sandy loams and loamy sands, and silty loams along the Pacific Coast shorelines and on alluvial plains. The mountains and foothills of the region include silty loams, cobbly silty loam, gravelly loam, sandy clay loams, clay loams, silty clays, and clays (SCAG 2011, UCCE 2014, SCS 1978, SCS 1986, SCS 1973). The inland region in Riverside and San Bernardino counties include sand to silty clays to cobbles and boulders on the alluvial fans, valley floor, terraces, and mountains, and dry lake beds (CVWD 2011).

11.3.3.9 Subsidence

Subsidence in the Central Coast and Southern California regions occur due to soil compaction following groundwater withdrawals at rates greater than groundwater recharge rates, oil and gas withdrawal, seismic activity, and hydroconsolidation of soils along alluvial fans (Los Angeles 2005). The USGS described areas with subsidence related to groundwater overdraft in the Central Coast and Southern California regions in San Luis Obispo, Santa Barbara, Los Angeles, Riverside, and Santa Bernardino counties (USGS 1999, Ventura County 2011, Los Angeles 2005, RCIP 2000). Many of the areas with subsidence have alluvial unconsolidated sands and silty sands with lenses of silt and clayey silt.

A recent study by the USGS in the southern Coachella Valley portion of Riverside described land subsidence of about 0.5 feet between 1930 and 1996 (USGS 2013c). Groundwater elevations in this area had declined since the early

1920s until 1949 when water from the Colorado River was provided to the area. This area is served by Coachella Valley Water District; and as described in Chapter 5, Surface Water Resources and Water Supply, the availability of surface water has not always been available to this area in recent years. The recent USGS study indicated that land subsidence of up to approximately 0.4 feet have occurred at some locations between 1996 and 2005; and possibly greater subsidence at other locations. A Coachella Valley Water District study indicated that up to 13 inches have occurred in parts of the valley between 1996 and 2005 (CVWD 2011).

11.4 Impact Analysis

This section describes the potential mechanisms and analytical methods for change in soils resources, results of the impact analysis, potential mitigation measures, and cumulative effects.

11.4.1 Potential Mechanisms for Change in Soils Resources

As described in Chapter 4, Approach to Environmental Analysis, the impact analysis considers changes in soils resources 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 change soil erosion potential due to crop idling on lands irrigated with CVP and SWP water supplies and along rivers downstream of CVP and SWP reservoirs, and potential changes in soils as lands are converted to seasonal floodplain or tidal-influenced wetlands.

11.4.1.1 Changes in Soil Erosion

Changes in CVP and SWP operations under the alternatives could change the extent of irrigated acreage and the potential for soil erosion on crop idled lands over the long-term average condition and in dry and critical dry years as compared to the No Action Alternative and the Second Basis of Comparison.

Changes in CVP and SWP operations under the alternatives also could change peak flows in rivers downstream of CVP and SWP reservoirs in the Trinity River and Central Valley regions as compared to historical conditions which could lead to soil erosion during high peak flow events during storms in wet years along the river banks as compared to the No Action Alternative and the Second Basis of Comparison. However, as described in Chapter 5, Surface Water Resources and Water Supplies, the results of the analysis indicate that peak flows would be within historical range of peak flows in these rivers and would be similar under Alternatives 1 through 5, No Action Alternative, and Second Basis of Comparison. Therefore, changes in CVP and SWP operations would not result in changes to peak flow events that could result in soil erosion along these rivers. Therefore, these changes are not analyzed in this EIS.

11.4.1.2 Changes in Soils at Restored Wetlands

Restoration of seasonal floodplains and tidally-influenced wetlands would affect soils resources at the restoration locations. However, these actions would occur in a similar manner under the No Action Alternative, Alternatives 1 through 5, and Second Basis of Comparison, as described in Chapter 3, Description of Alternatives; in addition, the conditions of the soils would be the same under all of the alternatives and the Second Basis of Comparison. Therefore, these changes are not analyzed in this EIS.

11.4.1.3 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 use 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 soil 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 surface water 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.

11.4.2 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. However, the changes to soils resources 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.

11.4.2.1 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

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 would also 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.

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 under the No Action Alternative and the Second Basis of Comparison. However, the CVP and SWP water deliveries would be less under the No Action Alternative as compared to the Second Basis of Comparison, as described in Chapter 5, Surface Water Resources and Water Supplies, which could result in more crop idling that could be subject to erosion.

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 result in disruption of soils resources; however, the development of general plans includes preparation of environmental documentation that would identify methods to minimize adverse impacts to soils resources.

Under the No Action Alternative and the Second Basis of Comparison, development of future water resources management projects by 2030 which would result in disruption of soils resources. However, the development of these future programs would include preparation of environmental documentation that would identify methods to minimize adverse impacts to soils resources.

By 2030 under the No Action Alternative and the Second Basis of Comparison, it is assumed that ongoing programs would result in restoration of more than 10,000 acres of intertidal and associated subtidal wetlands in Suisun Marsh and Cache Slough; and 17,000 to 20,000 acres of seasonal floodplain restoration in the Yolo Bypass.

11.4.3 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. The evaluation of alternatives is focused on portions of the Central Valley, San Francisco Bay Area, Central Coast, and Southern California regions that use CVP and SWP water for irrigation.

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

11.4.3.1 No Action Alternative

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

11.4.3.1.1 Central Valley Region

Potential Changes in Soil Erosion

As described in Chapter 12, Agricultural Resources, the extent of irrigated acreage under the No Action Alternative would be similar (within 5 percent) to the conditions under the Second Basis of Comparison over long-term conditions (throughout the 81-year model simulation period) and during dry and critical dry years due to the increased use of groundwater.

Effects Related to Cross Delta Water Transfers

Potential effects to soils 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 soils resources were identified as increased erosion and shrinking of expansive soils in the seller's service areas if crop idling is used to provide water for transfers; and increased potential for shrinking of expansive soils and soil movement in areas that use the transferred water. The analysis indicated that these potential impacts would not be substantial because farmers manage idle fields as part of normal agricultural operations and they would continue to use the same practices to avoid erosion impacts. The analysis also indicated that shrinking and soil movement occur as part of normal planting and harvesting practices and the changes with the water transfer programs would not result in substantial changes.

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 U.S. Fish and Wildlife Service (USFWS) Biological Opinion (BO) and the 2009 National Marine Fisheries Service (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.

11.4.3.1.2 San Francisco Bay Area, Central Coast, and Southern California Regions

Potential Changes in Soil Erosion

As described in Chapter 12, Agricultural Resources, the extent of irrigated acreage under the No Action Alternative is anticipated to be similar as conditions under the Second Basis of Comparison due to the increased use of groundwater.

11.4.3.2 Alternative 1

Alternative 1 is identical to the Second Basis of Comparison. Alternative 1 is compared to the No Action Alternative and the Second Basis of Comparison. However, because CVP and SWP operations conditions under Alternative 1 are identical to conditions under the Second Basis of Comparison; Alternative 1 is only compared to the No Action Alternative.

11.4.3.2.1 Alternative 1 Compared to the No Action Alternative

Central Valley Region

Potential Changes in Soil Erosion

As described in Chapter 12, Agricultural Resources, the extent of irrigated acreage under Alternative 1 would be similar to conditions under the No Action Alternative over long-term conditions and during dry and critical dry years due to the increased availability of CVP and SWP water supplies.

Effects Related to Cross Delta Water Transfers

Potential effects to soils 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 impacts on soils resources 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.

San Francisco Bay Area, Central Coast, and Southern California Regions

Potential Changes in Soil Erosion

As described in Chapter 12, Agricultural Resources, the extent of irrigated acreage under Alternative 1 is anticipated to be similar as conditions under the No Action Alternative due to increased availability of CVP and SWP water supplies.

11.4.3.2.2 Alternative 1 Compared to the Second Basis of Comparison

Alternative 1 is identical to the Second Basis of Comparison.

11.4.3.3 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 soils resources conditions under Alternative 2 are only compared to the Second Basis of Comparison.

11.4.3.3.1 Alternative 2 Compared to the Second Basis of Comparison

Changes to soils resources under Alternative 2 as compared to the Second Basis of Comparison would be the same as the impacts described in Section 11.4.3.1, No Action Alternative.

11.4.3.4 Alternative 3

The 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.

11.4.3.4.1 Alternative 3 Compared to the No Action Alternative

Central Valley Region

Potential Changes in Soil Erosion

As described in Chapter 12, Agricultural Resources, the extent of irrigated acreage under Alternative 3 would be similar to the conditions under the No Action Alternative over long-term conditions and during dry and critical dry years due to the increased availability of CVP and SWP water supplies.

Effects Related to Cross Delta Water Transfers

Potential effects to soils 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 impacts on soils resources 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.

San Francisco Bay Area, Central Coast, and Southern California Regions

Potential Changes in Soil Erosion

As described in Chapter 12, Agricultural Resources, the extent of irrigated acreage under Alternative 3 is anticipated to be similar to conditions under the No Action Alternative due to increased availability of CVP and SWP water supplies.

11.4.3.4.2 Alternative 3 Compared to the Second Basis of Comparison

Central Valley Region

Potential Changes in Soil Erosion

As described in Chapter 12, Agricultural Resources, the extent of irrigated acreage under Alternative 3 would be similar to the conditions under the Second Basis of Comparison over long-term conditions and during dry and critical dry years due to the increased use of groundwater.

Effects Related to Cross Delta Water Transfers

Potential effects to soils 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 impacts on soils resources 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.

San Francisco Bay Area, Central Coast, and Southern California Regions

Potential Changes in Soil Erosion

As described in Chapter 12, Agricultural Resources, the extent of irrigated acreage under Alternative 3 is anticipated to be similar to conditions under the Second Basis of Comparison due to the increased use of groundwater.

11.4.3.5 Alternative 4

Soil resources conditions 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.

11.4.3.5.1 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 soil resources conditions under Alternative 4 as compared to the No Action Alternative would be the same as the impacts described in Section 11.4.3.2.1, Alternative 1 Compared to the No Action Alternative.

11.4.3.6 Alternative 5

The 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.

11.4.3.6.1 Alternative 5 Compared to the No Action Alternative

Central Valley Region

Potential Changes in Soil Erosion

As described in Chapter 12, Agricultural Resources, the extent of irrigated acreage under Alternative 5 would be similar to conditions under the No Action Alternative over long-term conditions and during dry and critical dry years because the availability of CVP and SWP water supplies would be similar.

Effects Related to Cross Delta Water Transfers

Potential effects to soils 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 impacts on soils resources 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.

San Francisco Bay Area, Central Coast, and Southern California Regions

Potential Changes in Soil Erosion

As described in Chapter 12, Agricultural Resources, the extent of irrigated acreage under Alternative 5 is anticipated to be similar as conditions under the No Action Alternative because CVP and SWP water deliveries would be similar.

11.4.3.6.2 Alternative 5 Compared to the Second Basis of Comparison

Central Valley Region

Potential Changes in Soil Erosion

As described in Chapter 12, Agricultural Resources, the extent of irrigated acreage under Alternative 5 would be similar to the conditions under the Second Basis of Comparison over long-term conditions and during dry and critical dry years due to increased use of groundwater.

Effects Related to Cross Delta Water Transfers

Potential effects to soils 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 impacts on soils resources 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 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 Alternative 5 as compared to the Second Basis of Comparison.

San Francisco Bay Area, Central Coast, and Southern California Regions

Potential Changes in Soil Erosion

As described in Chapter 12, Agricultural Resources, the extent of irrigated acreage under Alternative 5 is anticipated to be similar to conditions under the Second Basis of Comparison due to the increased use of groundwater.

11.4.3.7 Summary of Impact Analysis

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 11.1 and 11.2, respectively.

Table 11.1 Comparison of Alternatives 1 through 5 to No Action Alternative

Alternative	Potential Change	Consideration for Mitigation Measures
Alternative 1	No effects on soils resources	None needed
Alternative 2	No effects on soils resources	None needed
Alternative 3	No effects on soils resources	None needed
Alternative 4	No effects on soils resources	None needed
Alternative 5	No effects on soils resources	None needed

Table 11.2 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	No effects on soils resources	Not considered for this comparison
Alternative 1	No effects on soils resources	Not considered for this comparison
Alternative 2	No effects on soils resources	Not considered for this comparison
Alternative 3	No effects on soils resources	Not considered for this comparison
Alternative 4	No effects on soils resources	Not considered for this comparison
Alternative 5	No effects on soils resources	Not considered for this comparison

11.4.3.8 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.

Changes in CVP and SWP operations under Alternatives 1 through 5 as compared to the No Action Alternative would not result in changes in soils resources. Therefore, there would be no adverse impacts to soils resources as compared to the No Action Alternative; and no mitigation measures are required.

11.4.3.9 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 Geology and Soils Resources are summarized in Table 11.3.

Table 11.3 Summary of Cumulative Effects on Geology and Soils Resources with Implementation of Alternatives 1 through 5 as Compared to the No Action Alternative

Scenarios	Actions	Cumulative Effects of Actions
Past & Present, and Future Actions	Consistent with Affected Environment conditions plus:	These effects would be the same under all alternatives.

Scenarios	Actions	Cumulative Effects of Actions
included in the No Action Alternative and in All Alternatives in Year 2030	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 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): - Climate Change and Sea Level Rise - 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 - General plans for 2030. - Trinity River Restoration Program. - Central Valley Project Improvement Act programs - Folsom Dam Water Control Manual Update - Dutch Slough Tidal Marsh Restoration - Suisun Marsh Habitat Management, Preservation, and Restoration Plan Implementation - Tidal Wetland Restoration: Yolo Ranch, Northern Liberty Island Fish Restoration Project, Prospect Island Restoration Project, and Calhoun Cut/Lindsey Slough Tidal Habitat Restoration Project - San Joaquin River Restoration Program - Grasslands Bypass Project - Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS) - Future water supply projects, including water recycling, desalination, groundwater banks	Developments under the general plans and future water supply, water quality improvement, and restoration projects could affect soils resources. However, development of these future programs would include preparation of environmental documentation that would identify methods to minimize adverse impacts to soils resources. 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 soils resources.

Scenarios	Actions	Cumulative Effects of Actions
	and wellfields, and conveyance facilities (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): - Bay-Delta Water Quality Control Plan Update - FERC Relicensing Projects - Bay Delta Conservation Plan and California WaterFix - Shasta Lake Water Resources, North-of-the-Delta Offstream Storage, Los Vaqueros Reservoir Expansion Phase 2, and Upper San Joaquin River Basin Storage Investigations - El Dorado Water and Power Authority Supplemental Water Rights Project - Semitropic Water Storage District Delta Wetlands - North Bay Aqueduct Alternative Intake - Irrigated Lands Regulatory Program - San Luis Reservoir Low Point Improvement Project - Westlands Water District v. United States Settlement - 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)	These effects would be the same in all alternatives. Developments under the future projects are anticipated to potentially effect soils resources. However, development of these future programs would include preparation of environmental documentation that would identify methods to minimize adverse impacts to soils resources. Some of the future cumulative effects 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 soils resources.
No Action Alternative with Associated Cumulative Effects Actions in Year 2030	Full implementation of the 2008 USFWS BO and 2009 NMFS BO	Implementation of the No Action Alternative with reasonably foreseeable actions would include developments under general plans and future water supply, water quality improvement, and restoration projects are anticipated to potentially affect soils resources. However,

Scenarios	Actions	Cumulative Effects of Actions
		development of these future programs would include preparation of environmental documentation that would identify methods to minimize adverse impacts to soils resources.
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 reasonably foreseeable actions would result in similar changes as under the No Action Alternative with the added actions.
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 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 similar changes 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) Slight increase in positive Old and Middle River flows in the winter and spring months	Implementation of Alternative 3 with reasonably foreseeable actions would result in similar changes as under the No Action Alternative with the added actions.
Alternative 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 Alternative 4 with reasonably foreseeable actions would result in similar changes as under the No Action Alternative with the added actions.
Alternative 5 with Associated Cumulative Effects Actions in Year 20530	Full implementation of the 2008 USFWS BO and 2009 NMFS BO 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 changes as under the No Action Alternative with the added actions.

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Figure 11.1 Geomorphic Provinces in California

Chapter 12

Agricultural Resources

12.1 Introduction

This chapter describes agricultural resources 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 land use through potential changes in operation of the Central Valley Project (CVP) and State Water Project (SWP) and ecosystem restoration.

Changes in non-agricultural land use and resources are described in Chapter 13, Land Use.

12.2 Regulatory Environment and Compliance Requirements

Potential actions that could be implemented under the alternatives evaluated in this EIS could affect agricultural resources 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.

12.3 Affected Environment

This section describes agricultural resources that could be potentially affected by the implementation of the alternatives considered in this EIS. Changes in agricultural 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. Direct or indirect agricultural resource effects due to implementation of the alternatives analyzed in this EIS are related to changes in agricultural land uses due to the availability and reliability of CVP and SWP water supplies.

Changes in agricultural resources can affect agriculture throughout the state. An overview of California agriculture is presented prior to discussions of agricultural resources in each of the regions.

12.3.1 Overview of California Agriculture

California agriculture is an important resource that produces over 400 types of crops. California is the nation’s leading producer of nearly 80 commodities; and produces more than 99 percent of the nation’s almonds, artichokes, dates, figs, raisins, kiwifruit, olives, clingstone peaches, pistachios, prunes, pomegranates, and walnuts (USDA-NASS 2012). In 2011, cultivation of 25.4 million acres of agricultural land contributed about $43.5 billion to California's economy and 11.6 percent of total agricultural revenues in the United States. This section provides:

- Recent trends in California agricultural resources
- Crop production practices
- Cropping pattern changes in response to water supply availability
- Water supply and crop acreage relationships in the San Joaquin Valley

12.3.1.1 Recent Trends in Agricultural Production

The United States Department of Agriculture (USDA) National Agricultural Statistics Service (NASS) California Field Office publishes annual reports containing data from County Agricultural Commissioners and periodic statewide census of agricultural producers. County Agricultural Commissioners' data covers acres planted, total production, prices, yield per acre, and value of production across crop groups and counties.

From 1960 to 2012, total acreage in production fluctuated between eight and nine million acres, as summarized in Figure 12.1. Over the last fifteen years, total acreage has trended down. Most of the variability over time, and the more recent downward trend, are largely attributable to changes in field and forage crop acreage. The percentage of field and forage acreage decreased from 77 percent of total acreage in 1960 to 48 percent in 2012. The proportion of acreage of permanent crops (e.g. orchards and vine) has steadily increased from 1960 to 2012. Orchard and vine acreage rose from 14 percent of total acreage in 1960 to 38 percent in 2012.

From 1960 to 2012, statewide annual value of production rose from $20 billion (all values are in 2012 US dollars) to $45 billion, as summarized in Figure 12.2. Of the crop categories, orchard and vine values grew the fastest over this period, from around $3 billion in annual value of production in 1960 to over $17 billion in 2012. This increase may be attributable to both the expansion of acreage planted, as shown in Figure 12.1, as well as price and yield increases. Orchard and vine values of production rose from 17 percent of the total statewide value of production in 1960 to 38 percent in 2012. Other crop categories that have also experienced an increase in value of production over this time period are: vegetable, livestock, dairy and poultry, and nursery. Field crops have shown a downward trend. The percentage from field and forage crops decreased from the peak of 28 percent of state value of production in 1980 to 11 percent in 2012. Total value of production is influenced by both the acreage planted each year as well as market prices and yields.

12.3.1.2 Crop Production Practices

Crop production practices vary by crop and locational differences such as soil, slope, local climate, and water source and reliability. Production practices discussed in this subsection include:

- Crop rotation and fallowing.

- Crop water use.
- Crop irrigation methods.
- Crop responses to water quality.
- Crop drainage methods.
- Crop adaptation to changes in water supply availability.

12.3.1.2.1 Crop Rotation and Fallowing

Crop rotation is the planned variation in the crop grown on a given field. Growers rotate annual crops and some forage crops in order to control plant pests, diseases, and weeds, and to improve soil structure, microbial diversity, and nutrient and mineral availability. Growers select a series of crops that are compatible for rotation that are planned to be grown in a field in a succession of years and plan their operations schedule and build their on-farm infrastructure (e.g., equipment, facilities and staffing) to a scale that meets the production needs of those crop acreage mixes (Baldwin 2006).

Field fallowing is the practice of not planting a crop in a field for one or more growing seasons. Fallowing can be a planned part of the rotation, or may be a consequence of another event like water supply shortage, flooding, land improvement, or poor crop prices. Rotations are not fixed, so changes in market conditions or Federal farm programs can affect crop mix and the pattern and magnitude of fallowing.

Fallowed fields without cover crops can lose topsoil to surface drainage and wind erosion. Loss of topsoil to erosion reduces land productivity, and can reduce nearby crop yields and marketability.

12.3.1.2.2 Crop Water Use

Crop irrigation water use depends on crop type, stage of crop growth, soil moisture profile from winter rains, soil moisture holding capacity (total amount of water in the soil potentially available to plants), management of plant pests and diseases, weather conditions (solar radiation, temperature and humidity) and irrigation water use efficiency. Irrigation water use efficiency can be defined in different ways. The California Department of Water Resources (DWR) defines the agronomic water use fraction as the irrigation water beneficially used for necessary agronomic functions (e.g., transpiration, leaching, frost protection, germination) divided by the total applied water (DWR 2012). Applied irrigation water is transpired by plants (crops and weeds), percolates into the groundwater below the root zone (necessary salt leaching component or over-irrigation loss to groundwater), evaporates directly from water or soil surfaces, or runs off the field as surface drainage (Edinger-Marshall and Letey 1997).

Reuse of water from fields to irrigate other fields, often multiple times, occurs throughout California. As a result, relatively low field-level efficiency (agronomic water use fraction) can result in relatively high efficiency from a regional or basin perspective (DWR 2013a).

12.3.1.2.3 Crop Irrigation

Agricultural irrigation needs vary by season. In the winter, rainfall refills the soil moisture profile that was depleted from the crop root zone the previous summer and fall. If soil moisture is not adequate for planting of annual crops, pre-irrigation water is applied. Pre-irrigation and early growing season irrigations generally occur in the time period from March through May. Peak agricultural irrigation water supply demand generally occurs from the late spring through late summer. Permanent crops are irrigated post-harvest to refill the root zone. Post-harvest irrigation of annual crop land is sometimes used to help break down crop residue and suppress some pests and diseases, especially in rice fields.

Irrigation methods vary by area, soil, crop type, and existing facilities. Annual row crops are often sprinkler irrigated for crop germination and furrow irrigated for the rest of the season. Permanent crops are typically irrigated with drip, sprinkler, furrow, border, or flood irrigation methods. Irrigated pasture and alfalfa are typically irrigated with sprinkler or flood irrigation methods. Rice is generally irrigated with flood irrigation. Irrigation methods utilized in the Central Valley include:

- **Flood and Border Irrigation:** Water is released into a leveled field or block that is segmented into “checks” with a small berm to contain the water. Water applied to the check until it is flooded and the water seeps into the ground or some is allowed to drain off the lower elevation end of the field.
- **Furrow Irrigation:** Water is released into furrows at the higher side of the field and flows down to the lower end of the field. To provide adequate water to the low end of the field, surface irrigation requires that a certain amount of water be spilled or drained off as tailwater. Recycling the tailwater to the head of the field or to an adjacent field can significantly increase overall efficiency. Furrow irrigation is used on annual row crops and on some vineyards.
- **Sprinkler Irrigation:** Sprinkler irrigation uses pressurized water through movable or solid set pipe to a sprinkler. Sprinklers lose some irrigation water to evaporation in the air before the water reaches the ground. Sprinklers also apply water to ground that does not have crop roots, and this applied water goes to surface evaporation, weed transpiration, or percolation to groundwater leaching. Sprinklers are often used during the germination stage of vegetables, and can also be used for frost control on orchards, especially citrus. Sprinkler irrigation can be used on most crops except those for which direct contact with the water drops could cause fruit cracking, fungal growth, or other issues.
- **Surface Drip and Micro-sprinkler Irrigation:** Surface drip and micro-sprinkler irrigation also use pressurized water that is delivered through flexible tubes to drip emitters or micro-sprinkler heads. Surface drip irrigation generally applies water only to the crop root areas. Drip irrigation and micro-sprinklers are used on most orchards and vineyards.

- **Subsurface Drip Irrigation:** Subsurface drip irrigation is similar to the drip irrigation described above, but the tubing or drip tape is buried a few inches to several feet, depending on the crop. Subsurface drip irrigation generally applies water only to crop root areas and reduces surface evaporation. Subsurface drip is used on some row crops and vineyards.

Flood and furrow irrigated acreage has declined over time, especially for trees and vines by drip and micro-sprinkler irrigation (NCWA 2011). Crops that continue to rely upon flood irrigation, such as rice, have improved irrigation efficiency through the use of laser leveling of the fields. The use of furrow and flood irrigation has declined in California from 67 percent of the total irrigated acreage in 1991 to 43 percent in 2010 (DWR 2013a). During this same time period, the use of drip, micro-sprinkler, and subsurface drip irrigation increased from 16 percent of total irrigated acreage in 1991 to 42 percent in 2010.

12.3.1.2.4 Crop Response to Water Quality

Water quality of the surface water streams in the Central Valley is generally very suitable for agricultural production with low salinity, neutral acidity/alkalinity (i.e., pH), minerals, nutrients, and dissolved metal concentrations that are appropriate for agricultural uses. However, groundwater quality varies substantially across California, as described in Chapter 7, Groundwater Resources and Groundwater Quality.

Agricultural production can be affected by high salinity, minerals, and boron in the irrigation water and the soils. In the Sacramento Valley, water temperature can reduce crop yields; cold water is a particular concern for rice production (Roel et al., 2005). Irrigation water can carry debris and biological contaminants that affect agricultural operations and the value of crop production (USDA 2006).

High salinity concerns occur on agricultural lands receiving CVP and SWP water from the Delta. As described in Chapter 6, Surface Water Quality, surface waters in the Delta and lower San Joaquin River water frequently are characterized by high salinity. These waters are used by agricultural water users in the Delta and CVP and SWP water users located within and to the south of the Delta.

Evaporation and transpiration of irrigation water cause salts to accumulate in soils unless adequate leaching and drainage are provided (Reclamation 2005). High water tables with elevated concentrations of salts can draw the salinity vertically through the soil by capillary action into the plant root zone and cause damage to the plant. Excessive irrigation water salinity and accumulated soil salinity can adversely affect soil structure, reduce water infiltration rates, reduce seed germination, increase seedling mortality, impede root growth, impede water uptake by the plant (from increased osmotic pressure), reduce plant growth rate, and reduce yields.

All irrigation water adds soluble salts to the soil, including sodium, calcium, magnesium, potassium, sulfate, and chlorides (Grattan 2002). Salinity is usually measured either in parts per million of total dissolved solids or by electrical conductivity (EC). Water salinity of irrigation water is measured as “EC_w.”

Accumulated salts in the soil are measured as “EC_e.” The strength of the electrical conductivity depends upon the water temperature, types of salts, and salt concentrations.

High salinity can affect the amount of irrigation water applied for crop irrigation and necessary soil leaching component (washing soil salts out of the plant root zone) compared to the total quantity of irrigation water applied (Reclamation 2005). Irrigation in the San Joaquin Valley typically includes a salt leaching component. The leaching water generally conveys the salts into installed drains in the fields or into the groundwater. Therefore, in locations where adequate drainage does not exist, continued irrigation with high salinity water has increased groundwater salinity, as described in Chapter 7, Groundwater Resources and Groundwater Quality.

Table 12.1 presents EC_e and EC_w values for salinity tolerances of a range of crops grown in the Central Valley.

Table 12.1 Salinity Tolerance of Selected Crops (as percent of maximum yield)

	Crop Tolerance based on Soil Salinity (measured as EC_e)			**Crop Tolerance based on Water Salinity (measured as EC_w)**		
Crops[a, b]	**100%**	**50%**	**0%**[c]	**100%**	**50%**	**0%**[c]
Alfalfa	2.0	8.8	16	1.3	5.9	10
Almond[d]	1.5	4.1	6.8	1.0	2.8	4.5
Apricot[d]	1.6	3.7	5.8	1.1	2.5	3.8
Bean	1.0	3.6	6.3	0.7	2.4	4.2
Corn, sweet	1.7	5.9	10	1.1	3.9	6.7
Cucumber	2.5	6.3	10	1.7	4.2	6.8
Grape[e]	1.5	6.7	12	1.0	4.5	7.9
Peach	1.7	4.1	6.5	1.1	2.7	4.3
Rice (paddy)	3.0	7.2	11	2.0	4.8	7.6
Squash, Zucchini	4.7	10	15	3.1	6.7	10
Sudan Grass	2.8	14	26	1.9	9.6	17
Sugar Beet[e]	7.0	15	24	4.7	10	16
Tomato	2.5	7.6	13	1.7	5.0	8.4

Sources: Ayers and Westcot 1994; Grattan 2002; Maas and Hoffman 1977

Notes:

a. These data should be used as a guide to relative tolerances among crops. Absolute tolerances will change based upon climate, soil conditions, and cultural practices. Plants will tolerate about 2 deciSiemens per meter (dS/m) higher soil salinity (EC_e) than indicated if soils have high gypsum, however the water salinity (EC_w) tolerances do not change.

b. EC_e is average root zone salinity as measured by electrical conductivity of the saturation extract of the soil, and EC_w is electrical conductivity of the irrigation water, both reported in dS/m) at 25°C. The data is based upon a relationship between soil salinity and water salinity of $EC_e = 1.5\ EC_w$ with a 15 to 20 percent leaching fraction and a 40-30-20-10 percent water use pattern for the upper to lower quarters of the root zone.

c. The zero yield potential or maximum EC_e indicates the theoretical soil salinity (EC_e) at which crop growth ceases.

d. Tolerance evaluations are based on tree growth and not on yield.

e. For beets, which are more sensitive during germination, the EC_e should not exceed 3 dS/m in the seeding area for garden beets and sugar beets.

The most sensitive crops are affected when EC_e values exceed 1 dS/m, and include the following crops with threshold values: beans (1.0 dS/m); walnuts 1.1 dS/m), bulb onions (1.2 dS/m); grapes, peppers and almonds (1.5 dS/m); apricots (1.6 dS/m); corn and peaches (1.7 dS/m); alfalfa (2.0 dS/m); and cucumbers and tomatoes (2.5 dS/m).

In addition to salinity, boron is also a concern in some areas. Dry beans are one of the more boron sensitive crops with a threshold value of 0.75 to 1.0 mg/l in the soil water within the crop root zone.

12.3.1.2.5 Crop Drainage Methods

Agricultural crop surface and subsurface drainage is important for the suitability of agricultural production (DWR 2013a; Reclamation 2005; SJVDIP 1998). Drainage of most agricultural fields occurs by a combination of surface drainage and subsurface drainage. Poor drainage can lead to crop loss or damage from lack of soil oxygen availability for plant roots, pest infestations (e.g., pathogenic root fungi, such as *phytothora*), and salt accumulation in the root zone. High water tables, high salinity, and poor drainage can limit crop selection and limit the ability of farmers to use irrigation water to leach excess salts out of the crop root zone.

Surface water drainage from agricultural fields is collected in on-farm drainage ditches which are typically connected to larger drainage facilities. The drainage water either flows by gravity or is pumped into adjacent water bodies. Water quality issues related to disposal of surface water drainage can include high concentrations of sediment; nutrients from fertilizers; or residual organic carbon constituents from herbicides, pesticides, or nematicides. On-farm surface drainage systems sometimes include local methods to remove sediment or nutrients, such as the inclusion of vegetative strips to remove sediment and improve drain water quality (CALFED 2000). During the irrigation season, surface drainage water collected from irrigation can be recirculated for subsequent irrigation; however, this can lead to a long-term increase in soil salinity (DWR 2013a; SJVDIP 1998).

Subsurface drainage is used to control groundwater depth to avoid or limit its encroachment into the root zone of crops (Panuska 2011). For example in the Delta, subsurface and surface drainage is used not only to control groundwater depths related to irrigation practices, but also to control groundwater that seeps into the soils from the surface water that surrounds the islands and tracts. Areas in the western and southern San Joaquin Valley are affected by shallow, saline groundwater that accumulates due to irrigation; and the shallow groundwater is underlain by soils with poor drainage (CALFED 2000; DWR 2013a; SJVDP 1990; SJVDIP 1998; WWD 2013a, 2013b). Some areas of northern San Joaquin, Valley collect and discharge subsurface drainage to the San Joaquin River (Reclamation, 2013). Areas in the central and southern San Joaquin Valley manage poor drainage conditions by careful and integrated management of crop patterns, land retirement, irrigation methods and application rates, and/or drainage water reuse and blending, (USGS 2008; WRCD 2004).

12.3.1.2.6 Crop Adaptation in Response to Changes in Water Supply Availability

Farmers and water suppliers can react to changes in water supply in a range of ways. Some farmers adapt to variability by maintaining a mix of crops that can be shifted or fallowed in response to water supply changes. Some farmers have groundwater wells that can be used to replace surface water in times of shortage. Short term responses can also include reducing irrigation water application below what is needed to maintain full crop yield (water stressing). Over the long term, irrigation systems and management can be changed to apply less water. Decisions that farmers make in response to changes in water supply affect other aspects of their operations, and affect the economy of the surrounding community. For example, crop mix and irrigation methods affect the kinds of tractors and other equipment used on the farm.

Some types of on-farm infrastructure also are specialized for the crops grown including: grain driers and storage, hullers, fruit sorting and packing, fruit driers, cotton gins and cold storage plants. Crop-specific equipment, infrastructure, and marketing agreements may prevent a grower from change crops quickly due to changes in water supply availability.

Input suppliers, equipment dealers, labor force, and processing facilities are also dependent on, and affected by, cropping decisions. As crop types change, the mix of these related economic activities also change. This can happen over a period of time, but is difficult to achieve in the short term.

Response to Variability in CVP and SWP Water Supplies

Water availability provided by the CVP and SWP varies each year based upon hydrologic conditions and regulatory requirements, as described in Chapter 5, Surface Water Resources and Water Supplies. The CVP and SWP water supply allocations are initially announced in the late winter. The allocations can be revised throughout the spring months as the hydrologic conditions become more certain. Growers often delay finalizing some of their crop decisions until water supply allocations are announced as late as April or May. Delays in finalizing crop decisions also can result in delays in finalizing crop financing and orders to suppliers (e.g., seed, fertilizer), and contracting with labor suppliers and crop processors. Responses to variations in water allocations depend on many factors, including but not limited to: feasibility of alternative water supplies (availability, suitability of water quality, cost); types of crops grown and need for changes in equipment, processing, and labor; and long-term crop supply contracts and obligations, (WWD 2013a, 2013b). A study of changes that occurred during the 1986 through 1992 drought indicated that implementation of the changes will probably occur over a longer period of time and not necessarily during the water supply shortage, especially if groundwater or other surface water supplies can be obtained within the growing season (Dale et al. 1998).

The effects on the surrounding communities of the variability of CVP and SWP water supplies are discussed in Chapter 19, Socioeconomics, and Chapter 21, Environmental Justice.

Typical responses of a farmer or water supplier to increasing shortage of water supplies include the following actions.

- **Increase the use of groundwater**: Reduction in surface water supplies can induce substitution with groundwater using new or existing wells. Water supplies are used conjunctively in some areas with groundwater storage so that during surface water shortages, water historically used to recharge groundwater can be used for applied irrigation uses.
- **Use alternative/supplemental surface water supplies**: Alternative water supplies may include local exchanges or transfers of surface water, water transfers/purchases from more distant areas, and/or use of water stored in surface water reservoirs or groundwater banks. These all depend on the infrastructure to convey the water and the financial ability to pay for the alternatives water supplies.
- **Increased water use efficiency:** Reduced use of irrigation water may be achieved by on-farm system and irrigation management improvements, water reuse, water source blending, and delivery system improvements. Specific on-farm and delivery system improvements can include irrigation scheduling, field leveling, application system changes, and conveyance system loss reduction such as canal lining, spill reduction, and automation. Some of the changes require only management changes, such as irrigation scheduling, and can occur within the growing season. Other changes, such as conveyance system modifications, require capital investments and generally require several years to implement.
- **Field fallowing or changing to lower-water-use crops:** Fallowing, or temporary idling, reduces gross water use by the entire applied water amount, and reduces net water use by at least the evapotranspiration of the crop not planted. Typically fields with higher water use crops or lower value rotation crops would be the first fields to be fallowed. Farmers generally would avoid or minimize fallowing permanent crops or crops with long-term obligations (e.g., cannery contracts). A farmer receiving a partial allocation of water could decide to reduce irrigated acreage and transfer that acreage’s water allocation to the remaining fields in production or sell the water to other water users. A smaller reduction in water use can be achieved by switching from a crop using more water to one using less water (Dale et al. 1998). Permanent

crops, such as trees and vines, that are the least economically viable or that are approaching the end of their lifespan can be removed or abandoned, and the land fallowed until adequate water is available. In extreme dry periods, such as 2014 when there were no deliveries of CVP water to San Joaquin Valley water supply agencies with CVP water service contracts, permanent crops were removed because the plants would not survive the stress of no water or saline groundwater (Fresno Bee 2014).

- **Stress Irrigation:** Farmers generally try to irrigate to achieve maximum economic yield. For some permanent crops, severe pruning could reduce water use, but could reduce yield over multiple years (AgAlert 2010).

12.3.1.3 Cropping Pattern Changes in Response to Water Supply Availability

Conversion of farm lands to other land uses has occurred historically and continues to occur. Agricultural lands have been converted to different crop patterns, urban areas, habitat restoration, off-farm infrastructure (e.g., utilities and transportation), and on-farm infrastructure (e.g., storage, maintenance, and processing facilities). Crop conversions occur in response to changes in water supply reliability, changes in market demand for specific crops, and decisions to convert lands to urban or infrastructure land uses.

One method used to indicate changes in California agricultural acreage is related to a loss of the value of production on “Important Farmland” and “Grazing Land” acreages, as reported by the California Department of Conservation since 1988 (CDOC 2004). The comparison of the acreage of lands within each category can be used to identify trends in agricultural land conversions. This information is provided in the following subsections for the years 2000 and 2010 for counties within the study area.

Another factor to be considered prior to crop conversion is the costs related to crop establishment. Costs of irrigated crop production include labor, purchased inputs (e.g., seed, fertilizer, chemicals), custom services, investment in growing stock, other capital (including machinery and structures), and other overhead costs.

Reliability of water supply can be especially important for maintaining substantial investments in growing stock of perennial and multi-year crops. Perennial crops include orchards and vineyards that may have useful lives of 25 years or more. Multiyear forage crops, such as alfalfa and irrigated pasture, also may be in production for years. Investment in growing stock may be expressed as the accumulated costs incurred during the period when the crop is planted and brought to bearing age, called the establishment period. Establishment costs for perennial crops can range up to $15,000 per acre in total costs (including cash outlays plus noncash and allocated overhead costs). The example establishment costs provided in Table 12.2 are for the Central Valley, but are generally representative of establishment costs in other regions.

Table 12.2 Typical Establishment Costs for Some Perennial Crops in the Central Valley

Example Crop	Establishment Period (years)	Assumed Life of Stand (years)	Accumulated Total Cost during Establishment ($ per acre)	University of California Cooperative Extension Cost of Production Study
Alfalfa Hay	1	4	534	Sacramento Valley, 2013
Almonds	4	25	10,117	San Joaquin Valley North, 2011
Irrigated Pasture	1	20	408	Sacramento Valley, 2003
Walnuts	5	25	14,133	San Joaquin Valley North, 2013
Wine Grapes	3	25	18,495	Cabernet Sauvignon, SJ Valley North, 2012

Sources: UCCE 2003, 2011, 2012a, 2013a

Notes: All costs are converted to 2012 dollar equivalent values using the Gross Domestic Product Implicit Price Deflator (USDOC 2014). Assumed stand life is the financial life used for the cost and budget analysis. Individual growers may decide to keep stands in production longer or to remove them sooner.

Farm expenditures are largely spent in the surrounding community in the form of input purchases, hired labor, rents paid to landlords, well drilling, and custom consulting services. Total labor in the agricultural production sector is discussed in relation to the regional economy in Chapter 19, Socioeconomics. Labor hours and input purchases vary substantially among crops, as shown in Table 12.3.

Table 12.3 Land Rent, Labor Hours, and Custom Services for Example Crops in the Central Valley

Example Crop	Typical Rent ($ per acre)	Typical Annual Labor (hours per acre)	Custom Services Purchased ($ per acre)	University of California Cooperative Extension Cost of Production Study
Alfalfa Hay	284	2	368	Sacramento Valley, 2013
Almonds	763	31	828	San Joaquin Valley North, 2011
Corn, Grain	147	3	324	San Joaquin Valley South, 2012
Irrigated Pasture	63	3	159	Sacramento Valley, 2003
Rice	280	5	329	Sacramento Valley, 2012
Walnuts	690	8	1,203	San Joaquin Valley North, 2013
Wheat	246	2	57	San Joaquin Valley South, 2013
Wine Grapes	633	68	505	Cabernet Sauvignon, SJ Valley North, 2012

Sources: UCCE 2003, 2011, 2012a, 2012b, 2012c, 2013a, 2013b, 2013c

Notes: All costs are converted to 2012 dollar equivalent values using the Gross Domestic Product Implicit Price Deflator (USDOC 2014).

12.3.1.4 Water Supply and Crop Acreage Relationships in the San Joaquin Valley

Most publically-available information on irrigated acreage and crop types is compiled at the county level, not the water district level. Water availability for CVP and SWP water is provided at a smaller geographic level, such as a water supply entity or several adjacent entities. Therefore, it is difficult to analyze the correlation of water supply availability, irrigated acreage, and crop types. However, the Westlands Water District does provide more detailed information related to water availability, irrigated acreage, and crop types in their publically-available reports, as summarized in this sub-section of Chapter 12. The purpose of this summary is to describe the relationships between cropping patterns, irrigation methods, and water supply availability. Due to the increased frequency of water supply reductions, especially in drier years (as described in Chapter 5, Surface Water Resources and Water Supplies), the amount of fallowed and non-harvested lands has increased as a percentage of total lands within Westlands Water District. The trend observed in Westlands Water District of using additional groundwater and crop idling land when CVP and SWP water supplies are reduced; and reducing groundwater use and increasing irrigated acreage when CVP and SWP become more available occurs throughout the San Joaquin Valley.

12.3.1.4.1 Water Supplies in Westlands Water District

Formed in 1952, Westlands Water District currently serves over 700 farmers across 604,000 acres located on the west side of Fresno and Kings Counties, as described in Chapter 5, Surface Water Resources and Water Supplies (WWD 2013a, 2013b). There are approximately 568,000 irrigable acres in the district.

Westlands Water District began receiving CVP water in 1968. In the first 10 years of operations, irrigation water conveyance facilities were completed and cropping patterns became established. The CVP water supplies were reduced during the 1976 to 1977 drought. Crop acreage and water supply information are available for Westlands Water District from 1978 through 2013 (WWD 2013a, 2014b, 2014c).

This time period includes several major happenings and/or changes in the CVP water supplies, as described in Chapter 5, Surface Water Resources and Water Supplies, and Chapter 6, Surface Water Quality.

- In 1978, the CVP water supplies were recovering from the 1976 to 1977 drought.
- In the late 1980s, high selenium concentrations were detected in subsurface drainage flows from areas on the west side of the San Joaquin Valley where naturally occurring selenium deposits are located. Subsequently, farmers in these areas changed irrigation practices and in some cases, eliminated irrigation of some lands.
- Between 1987 and 1992, another drought occurred.

- In mid-1990s, the CVP water supplies recovered from a six year drought; however, CVP water supplies available to the district were limited due to initial restrictions on CVP operations to protect winter-run Chinook salmon and delta smelt and to provide refuge water supplies in accordance with the federal Central Valley Project Improvement Act (Public Law 102-575).
- By 2000, the CVP was initially operated under the requirements of State Water Resources Control Board Decision 1641 and the federal Central Valley Project Improvement Act which reduced the long-term availability of CVP water as compared to the 1980s.
- In 2007, the CVP operations were modified in accordance with the Interim Remedial Order issued by the U.S. District Court for the Eastern District of California in *Natural Resources Defense Council, et al. v. Kempthorne*.
- In 2009, the CVP operations were modified in accordance with the 2008 U.S. Fish and Wildlife Service and 2009 National Marine Fisheries Services biological opinions.
- Between 2007 and 2013, six of the seven years were designated as Below Normal, Dry, or Critical Dry water years, which reduced CVP water supplies.

As CVP water supplies have declined over the past 35 years, Westland Water District has needed to implement major conservation programs and purchase water from other CVP and SWP water users and water rights holders. Concurrently, growers have increased groundwater pumping, as illustrated in Figure 12.3. Total supply over this time period ranges from a low of 787,554 acre-feet in 2010 to a high of 1,546,883 acre-feet in 1984 (WWD 2013a, 2014a).

12.3.1.4.2 Cropping Patterns in Westlands Water District

In response to varying water supplies and market factors, farmers in Westlands Water District have changed cropping patterns. In 1978, the predominant crops were cotton and grain crops, including wheat and barley, with some vegetables, including tomatoes and cantaloupe, as summarized in Figure 12.4 (WWD 2013a). Between 1980 and 1996, grain crops were replaced by vegetable crops because other areas in California that traditionally grew crops were experiencing urbanization and groundwater shortages, including southern Santa Clara County and Monterey County (WWD 2008). Planting of permanent crops, including orchards and grapevines, increased between 1978 and 2013 as the markets factors became favorable (WWD 2013a, 2014b, 2014c). Total cotton acreage remained stable between 1978 and 2000, with Acala cotton as the primary crop (WWD No Date-a, No Date-b). After 2000, the total acreage of cotton declined and the primary crop was Pima cotton due to higher market price for this crop; however, cotton prices declined in the early 2000s.

12.3.1.4.3 Irrigation Methods in Westlands Water District

Conversion of the major crops from annual grains to more orchards and vines resulted in Westlands Water District modifying water conveyance facilities because the water demand patterns changed both in quantities and seasonal timing (WWD No Date-c). The change in cropping patterns and the concurrent emphasis on water conservation also resulted in changes in irrigation methods within the district, as summarized in Table 12.4.

Table 12.4 Irrigation Methods Used in Westlands Water District, as a percentage of total irrigation methods

Years	Furrow or Border Strip Irrigation	Sprinkler Irrigation	Drip or Trickle Irrigation	Sprinkler and Furrow Irrigation
1985	63%	21%	1%	15%
1990	43%	16%	3%	38%
1995	36%	15%	6%	43%
2000	30%	13%	13%	44%
2005	23%	10%	33%	34%
2010	11%	11%	67%	22%
2011	13%	12%	65%	22%

Source: WWD 2013a

These changes represent a major investment by the farmers and are considered in the cost of crop establishment costs, a consideration described in above in subsection 12.32.3.1, Crop Establishment Costs. The lower-valued grain and forage crops generally use furrow or border strip irrigation (WWD 2013a). Shallow-rooted vegetables frequently are irrigated with sprinklers or a combination of sprinklers and furrow irrigation. Recently, tomatoes for fresh-pack have been grown with drip irrigation. New orchard and vines have been planted with pressurized drip or trickle irrigation. Other methods, including leveling lands with lasers guided by global positioning satellites and aerated irrigation to introduce air to plant roots, are used to increase irrigation efficiency and improve crop yield (WWD No Date-a).

12.3.1.4.4 Response to Reduced Water Supplies in Westlands Water District

Westlands Water District acquired over 95,000 acres of land with inadequate drainage and the water supplies allocated to these lands are now available for other lands in the district (WWD 2008, 2013a, No Date-c). Much of the purchased land is leased to farmers for non-irrigated crops, or made available for buildings or other economic development, including about 600 acres to the U.S. Bureau of Prisons and about 1,250 acres to Pacific Gas & Electric Company for solar projects.

Frequently, the amount of available surface water is not adequate to meet the irrigation water demand. For example in the drier years of 1991, 1992, 2009, and 2013, groundwater provided more than 50 percent of the irrigation water supply. This extensive reliance on groundwater can substantially reduce groundwater elevations, as described in Chapter 7, Groundwater Resources and Groundwater Quality.

The Westlands Water District *Water Management Handbook* discusses that during droughts, water supplies are reduced and the cost of available water supplies are generally high due to costs of water transfers and/or implementing new or expanded groundwater facilities (WWD 2013b). At the farm level, Westlands' growers use a mix of methods to respond to reduced water supplies: groundwater pumping, land fallowing, and stress irrigation. The decision to fallow land or stress crops by applying less than full irrigation depends upon the crop. Some crops require full irrigation in order to produce a profitable yield, so stress irrigation is not practical – if water is short, acreage of these crops is reduced. Other crops may be able to withstand some stress and produce profitable yield. In the most severe shortage years, such as 2014, even some orchards and vineyards may be stressed or removed from production. From 1978 through the late 1990s when the primary crops were grains and cotton, those crops continued to be grown under stressed conditions and the fallowed and non-harvested land ranged from 3 to 16 percent of the total land in the district, as summarized in Figure 12.5 (WWD 2013a, 2014b, 2014c). However, since 2000, over 40 to 55 percent of the total land in the district is planted in high value orchards, vine, and vegetable crops which cannot sustain stress. Therefore, farmers have increased the amount of fallowed and non-harvested acres to 10 to 34 percent of the total land in the district. When permanent orchards and vines are removed from production, the overall value of production in the district declines for number of years as the permanent crops require several years to become established.

12.3.2 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.

Agriculture in the Trinity River Region is primarily related to timber products and cattle ranching which generally do not rely upon irrigation. Small farms and vineyards are located adjacent to or near the Trinity River rely primarily upon groundwater that is recharged by precipitation and infiltration from local streams, as described in Chapter 7, Groundwater Resources and Groundwater Quality. No lands in Trinity River Region are irrigated with water supplies delivered through the CVP or SWP.

Total value of production and acreage by crop category in the counties that include portions of the Trinity River Region are listed in Table 12.5.

Table 12.5 Average Annual Agricultural Acreage and Value of Production in Trinity, Humboldt, and Del Norte Counties from 2007 through 2012

	Orchards, Vineyards, and Berries	Field and Forage	Livestock, Dairy, Poultry	Nursery, Other	Vegetable	Total
Acreage[a]	114	30,846	N/A	231	–	31,191
Value[b]	$1.8	$8.1	$108.2	$64.5	$1.7	$184

Sources: USDA-NASS2008, 2009, 2010, 2011a, 2012a, 2013a

Notes:

a. Not all acreages and/or production values are reported for every crop in every county. Therefore the implied value of production per acre may be misleading for some crop categories.

b. Values in million dollars, 2012 basis.

12.3.3 Central Valley Region

The Central Valley Region extends from above Shasta Lake to the Tehachapi Mountains, and includes the Sacramento Valley and San Joaquin Valley. In this chapter, the counties within the Delta and Suisun Marsh area are included in the description of the Sacramento and San Joaquin valleys or the San Francisco Bay Area Region. The Delta counties of Sacramento, Yolo, and Solano counties are included within the Sacramento Valley discussion. Solano County also includes the Suisun Marsh. San Joaquin County is included within the San Joaquin Valley discussion. Contra Costa County is included within the San Francisco Bay Area Region discussion.

Central Valley agriculture is highly productive due to favorable climate, adequate supplies of good quality irrigation water, and deep, fertile soils. Most of the Central Valley receives rainfall in the late fall through the winter months. Very little of the annual rainfall occurs during the peak agricultural irrigation season which extends from early spring through fall. The seasonality of rainfall in the Central Valley is important for agricultural resources, as the timing of precipitation does not reliably support dryland (non-irrigated) farming. Lower value over-winter non-irrigated crops (e.g., winter wheat) can be grown economically in many years but higher value row crops and permanent crops require substantial supplemental irrigation (DWR 2009). Irrigation water provided by the CVP and SWP, local surface water, and groundwater have transformed lands in the Central Valley into some of the most productive and diverse agricultural lands in the United States.

12.3.3.1 Sacramento Valley Crop Patterns

The Sacramento Valley includes the counties of Shasta, Plumas, Tehama, Glenn, Colusa, Butte, Sutter, Yuba, Nevada, Placer, El Dorado, Sacramento, Yolo, and Solano counties. Other counties in Sacramento Valley are not anticipated to be affected by changes in CVP and SWP operations, and are not discussed here, including: Alpine, Sierra, Lassen, and Amador counties.

Field and forage crops dominate the irrigated acreage in Sacramento Valley with over 1.4 million acres irrigated and about 38 percent of crop value produced, as summarized in Table 12.6. Rice, irrigated pasture, and hay are the largest acreages. Second to field and forage are orchard and vine crops, making up roughly 21 percent of total acreage, but providing more than 38 percent crop value produced. Almonds and walnuts are the largest acreages in this category. Crop establishment and production costs are as summarized in Tables 12.2 and 12.3. In total, the Sacramento Valley contains nearly two million agricultural acres generating over four billion dollars per year in value of production.

Table 12.6 Sacramento Valley Average Annual Agricultural Acreage and Value of Production from 2007 through 2012

	Orchards, Vineyards, and Berries	Field and Forage	Livestock, Dairy, Poultry	Nursery, Other	Vegetable	Total
Acreage[a]	419,263	1,435,923	N/A	1,658	91,684	1,948,527
Value[b]	$1,569	$1,581	$506	$135	$322	$4,113

Sources: USDA-NASS 2008, 2009, 2010, 2011a, 2012a, 2013a

Notes:

a. Not all acreages and/or production values are reported for every crop in every county. Therefore the implied value of production per acre may be misleading for some crop categories.

b. Values in million dollars, 2012 basis

Most of the counties within the Sacramento Valley have experienced losses in Important Farmland between 2000 and 2010, as summarized in Table 12.7.

Table 12.7 Farmland Mapping and Monitoring Program Acreages in the Sacramento Valley in 2000 and 2010

		Important Farmland[b]			Grazing Land		
County	**Total[a]**	**2000**	**2010**	**Change**	**2000**	**2010**	**Change**
Butte	1.08	257,316	237,351	-19,965	264,982	402,999	138,017
Colusa	0.72	565,890	554,695	-11,195	7,526	9,161	1,635
El Dorado	1.1	68,292	64,259	-4,033	203,798	193,883	-9,915
Glenn	0.84	407,906	348,147	-59,759	176,072	226,837	50,765
Nevada	0.64	21,973	25,934	3,961	129,758	116,808	-12,950
Placer	0.96	156,701	132,741	-23,960	23,708	24,193	485
Sacramento	1.1	227,931	211,744	-16,187	168,144	155,822	-12,322
Shasta	2.4	35,349	19,716	-15,633	409,479	414,052	4,573
Solano	0.58	169,934	147,464	-22,470	201,813	209,195	7,382
Sutter	0.39	301,176	285,820	-15,356	50,958	53,538	2,580
Tehama	1.7	244,782	231,592	-13,190	706,027	1,547,951	841,924
Yolo	0.65	409,796	374,534	-35,262	143,365	160,450	17,085
Yuba	0.41	90,173	82,538	-7,635	144,519	141,509	-3,010

Sources: Butte County 2010; CDOC 2013; Colusa County 2011; El Dorado County 2003; Glenn County 1993; Nevada County 1995; Placer County 2011; Sacramento County 2010; Shasta County 2004; Solano County 2008; Sutter County 2010; Tehama County 2008; Yolo County 2009; Yuba County 2011

Notes:

a. Total acreage of county in million acres

b. Includes Prime Farmland, Farmland of Statewide Importance, and Unique Farmland.

No data was reported by California Department of Conservation for Plumas County.

12.3.3.2 San Joaquin Valley

The San Joaquin Valley includes the counties of Stanislaus, Merced, Madera, San Joaquin, Fresno, Kings, Tulare, and Kern counties. Other counties in the San Joaquin Valley are not anticipated to be affected by changes in CVP and SWP operations, and are not discussed here, including: Calaveras, Mariposa, and Tuolumne counties.

Field and forage crops are also the largest category in by acreage in this region, as summarized in Table 12.8. Hay, cotton, and silage have the largest acreage in this category. Second to field and forage is orchard and vine crops with almost two million acres, but providing more than three times the value of production. Almonds and grapes are the two largest acreages of orchard and vine crops in the San Joaquin Valley. Crop establishment and production costs are as summarized in Tables 12.2 and 12.3. In total, the San Joaquin Valley contains over 5.5 million irrigated acres, generating over twenty-six billion dollars in value of production.

Important differences exist in water supply mix and reliability within the San Joaquin Valley. The CVP water users that are located on the west side of the valley and the SWP water users in Kings and Kern counties rely primarily on surface water conveyed through the Delta and groundwater, as discussed in Chapter 5, Surface Water Resources and Water Supplies. Agricultural producers within these CVP water service contractors and SWP entitlement holders are especially susceptible to large variation in available surface water supplies. The San Joaquin River Exchange Contractors receive CVP water supplies in exchange for their water rights on the San Joaquin River; and therefore, have much higher water supply reliability than CVP water service contractors or SWP entitlement holders, as described in Chapter 5, Surface Water Resources and Water Supplies.

On the east side of the San Joaquin Valley at the base of the Sierra Nevada, surface water is delivered under senior water rights on streams from the Sierra Nevada, or by the CVP from Millerton Lake at Friant Dam, as described in Chapter 5, Surface Water Resources and Water Supplies. The reliability of CVP water supplies from Friant Dam have generally been similar to or higher than that of CVP water supplies conveyed through the Delta. However, in 2014, the allocations were reduced to zero and available water from Friant Dam was provided to the water rights holders along the San Joaquin River (e.g., San Joaquin River Exchange Contractors).

A number of agricultural areas throughout the valley have no or very low priority surface water rights. Growers in these areas rely on groundwater for irrigation water.

Table 12.8 San Joaquin Valley Average Annual Agricultural Acreage and Value of Production from 2007 through 2012

	Orchards, Vineyards, and Berries	Field and Forage	Livestock, Dairy, Poultry	Nursery, Other	Vegetable	Total
Acreage[a]	1,943,549	3,078,803	N/A	3,838	510,370	5,536,560
Value[b]	$10,915	$3,049	$9,429	$469	$2,789	$26,651

Sources: USDA-NASS 2008, 2009, 2010, 2011a, 2012a, 2013a

Notes:

a. Not all acreages and/or production values are reported for every crop in every county. Therefore the implied value of production per acre may be misleading for some crop categories.

b. Values in million dollars, 2012 basis.

Most counties within the San Joaquin Valley Region have experienced losses in Important Farmland between 2000 and 2010, as summarized in Table 12.9. The acreage of Important Farmland in Kern County grew substantially due to reclassification of lands in the foothills of the county.

Table 12.9 Farmland Mapping and Monitoring Program Acreages in the San Joaquin Valley in 2000 and 2010

		Important Farmland[b]			Grazing Land		
County	Total[a]	2000	2010	Change	2000	2010	Change
Fresno	3.8	1,400,535	1,370,273	-30,262	835,870	825,752	-10,118
Kern	5.3	990,422	914,084	-76,338	1,777,640	1,827,391	49,751
Kings	0.82	607,274	552,087	-55,187	238,485	271,831	33,346
Madera	1.4	60,617	39,812	-20,805	216,795	231,475	14,680
Merced	1.3	374,762	361,582	-13,180	401,592	400,604	-988
San Joaquin	0.91	630,990	614,994	-15,996	150,341	139,235	-11,106
Stanislaus	0.94	386,534	403,802	17,268	375,367	429,544	54,177
Tulare	3.1	880,604	859,991	-20,613	434,047	440,042	5,995

Sources: CDOC 2013; Fresno County 2000; Kern County 2004; Kings County 2009; Madera County 1995; Merced County 2012; San Joaquin 2009; Stanislaus County 2010; Tulare County 2010

Notes:

a. Total acreage of county in million acres

b. Includes Prime Farmland, Farmland of Statewide Importance, and Unique Farmland

12.3.4 San Francisco Bay Area Region

The San Francisco Bay Area Region includes portions of Napa, Contra Costa, Alameda, Santa Clara, and San Benito counties that are within the CVP and SWP service areas.

Crops grown in the San Francisco Bay Area Region include berries, vegetables, orchards, nursery plants, and irrigated and non-irrigated pasture. Permanent crops (orchards, vineyards, and berries) cover the largest acreage in this region with around 60,000 acres planted, as summarized in Table 12.10. Field and forage crops and vegetables also cover substantial acreage. Crop establishment and production costs are generally similar to those shown in Tables 12.2 and 12.3, except that land costs and rent may be substantially higher in this region. In total, the San Francisco Bay Area Region contains about 150,000 acres planted, creating over one billion dollars per year in value of production.

Table 12.10 San Francisco Bay Area Average Annual Agricultural Acreage and Value from 2007 through 2012

	Orchards, Vineyards, Berries	Field and Forage	Livestock, Dairy, Poultry	Nursery, Other	Vegetable	Total
Acreage[a]	60,239	50,715	N/A	942	41,564	153,460
Value[b]	$589	$22	$62	$145	$329	$1,148

Sources: USDA-NASS 2008, 2009, 2010, 2011a, 2012a, 2013a

Notes:

a. Not all acreages and/or production values are reported for every crop in every county. Therefore the implied value of production per acre may be misleading for some crop categories.

b. Values in million dollars, 2012 basis

Changes in farmland in the San Francisco Bay Area Region counties are summarized in Table 12.11.

Table 12.11 Farmland Mapping and Monitoring Program Acreages in the San Francisco Bay Area Region in 2000 and 2010

		Important Farmland[b]			Grazing Land		
County	Total[a]	2000	2010	Change	2000	2010	Change
Alameda	0.47	10,346	7,566	-2,780	247,218	244,033	-3,185
Contra Costa	0.52	102,294	90,148	-12,146	172,053	168,646	-3,407
Napa	0.51	78,406	76,210	-2,196	180,920	179,029	-1,891
San Benito	0.89	81,701	57,460	-24,241	595,537	614,821	19,284
Santa Clara	0.84	44,025	27,751	-16,274	389,210	392,777	3,567

Sources: Alameda County 2000; CDOC 2013; Contra Costa County 2005; Napa County 2007; San Benito County 2013; Santa Clara County 1994

a. Total acreage of county in million acres

b. Includes Prime Farmland, Farmland of Statewide Importance, and Unique Farmland

12.3.5 Central Coast Region

The Central Coast Region includes portions of San Luis Obispo and Santa Barbara counties served by the SWP.

Crops grown in this region include orchards and vineyards, berries, vegetables, and irrigated pasture. Permanent crops and vegetables dominate the irrigated acreage in this region, accounting for about eighty percent of both the acres planted and the annual value of production, as summarized in Table 12.12. Crop establishment and production costs are generally similar to those shown in Tables 12.2 and 12.3, except that land costs and rent may be higher in this region. On average, the Central Coast Region contains almost 230,000 acres planted and almost two billion dollars per year in value of production.

Table 12.12 Central Coast Region Average Annual Agricultural Acreage and Value from 2007 through 2012

	Orchards, Vineyards, Berries	Field and Forage	Livestock, Dairy, Poultry	Nursery, Other	Vegetable	Total
Acreage[a]	86,394	43,078	N/A	1,749	97,17	228,397
Value[b]	$874	$22	$98	$268	$641	$1,904

Sources: USDA-NASS 2008, 2009, 2010, 2011a, 2012a, 2013a

Notes:

a. Not all acreages and/or production values are reported for every crop in every county. Therefore the implied value of production per acre may be misleading for some crop categories.

b. Values in million dollars, 2012 basis

Changes in farmland in the Central Coast Region between 2000 and 2010 are summarized in Table 12.13.

Table 12.13 Farmland Mapping and Monitoring Program Acreages in the Central Coast and Southern California Regions in 2000 and 2010

		Important Farmland[b]			Grazing Land		
County	**Total[a]**	**2000**	**2010**	**Change**	**2000**	**2010**	**Change**
San Luis Obispo	2.3	496,116	409,726	-86,390	1,105,169	1,181,015	75,846
Santa Barbara	1.8	139,810	125,292	-14,518	583,709	581,642	-2,067

Sources: CDOC 2013; San Luis Obispo County 2013; Santa Barbara County 2009

Notes:

a. Total acreage of county in million acres

b. Includes Prime Farmland, Farmland of Statewide Importance, and Unique Farmland

12.3.6 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.

Two crop categories, orchards, vineyards, and berries; and field and forage, account for more than three quarters of the irrigated acreage and about sixty percent of the annual value of production in the Southern California Region, as summarized in Table 12.14). Vegetables account for about one fifth of the irrigated acreage and production value. Crop establishment and production costs are generally similar to those shown in Tables 12.2 and 12.3, except that land costs and rent may be higher in parts of this region. In total, the Southern California Region contains almost 380,000 acres irrigated and generates over five billion dollars per year in value of production.

Table 12.14 Southern California Average Annual Agricultural Acreage and Value from 2007 through 2012

	Orchards, Vineyards, Berries	Field and Forage	Livestock, Dairy, Poultry	Nursery, Other	Vegetable	Total
Acreage[a]	141,447	143,747	N/A	10,143	81,306	376,642
Value[b]	$1,693	$161	$809	$1,851	$925	$5,439

Sources: USDA-NASS 2008, 2009, 2010, 2011a, 2012a, 2013a

Notes:

a. Not all acreages and/or production values are reported for every crop in every county. Therefore the implied value of production per acre may be misleading for some crop categories.

b. Values in million dollars, 2012 basis

Changes in farmland in the Southern California Region between 2000 and 2010 are summarized in Table 12.15.

Table 12.15 Farmland Mapping and Monitoring Program Acreages in the Southern California Region in 2000 and 2010

		Important Farmland[b]			Grazing Land		
County	Total[a]	2000	2010	Change	2000	2010	Change
Los Angeles	2.6	60,617	39,812	-20,805	216,795	231,475	14,680
Orange	0.61	16,953	7,264	-9,689	37,963	37,639	-324
Riverside	4.7	484,821	428,989	-55,832	124,714	110,841	-13,873
San Bernardino	12.9	44,738	22,761	-21,977	936,090	902,590	-33,500
San Diego	2.9	193,103	218,921	25,818	137,619	126,496	-11,123
Ventura	1.2	131,512	119,683	-11,829	208,752	197,278	-11,474

Sources: CDOC 2013; Los Angeles County 2011; Orange County 2005; RCIP 2000; San Bernardino County 2007; San Diego County 2011; Ventura County 2005

Notes:

a. Total acreage of county in million acres

b. Includes Prime Farmland, Farmland of Statewide Importance, and Unique Farmland

12.4 Impact Analysis

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

12.4.1 Potential Mechanisms for Change in Agricultural Resources

As described in Chapter 4, Approach to Environmental Analysis, the impact analysis considers changes in agricultural resources 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 change irrigated acreage and total production value in areas that use CVP and SWP water supplies under long-term conditions (based upon the 81-year model simulation period) and dry and critical dry years.

This chapter only includes the analysis of economic changes in agricultural revenues. Chapter 19, Socioeconomics, includes economic changes related to municipal and industrial water supplies and changes in regional economics.

12.4.1.1 Changes in Irrigated Agricultural Acreage and Total Production Value

Changes in CVP and SWP operations under the alternatives could change the extent of irrigated acreage and total production value over the long-term average condition and in dry and critical dry years as compared to the No Action Alternative and Second Basis of Comparison.

The results of the impact analysis represents comparison of long-term changes that would occur between alternatives by 2030. The impact analysis does not represent short-term responses, especially during one to five years, in response to emergency flood or drought conditions.

Agricultural impacts were evaluated using a regional agricultural production model developed for large-scale analysis of irrigation water supply and cost changes. The Statewide Agricultural Production (SWAP) model is a regional model of irrigated agricultural production and economics that simulates the decisions of producers (farmers) in 27 agricultural subregions in the Central Valley Region, as described in Appendix 12A. The model selects the crops, water supplies, and other inputs that maximize profit subject to constraints on water and land, and subject to economic conditions regarding prices, yields, and costs.

The SWAP model incorporates CVP and SWP water supplies, other local water supplies represented in the CalSim II model, and groundwater. As conditions change within a SWAP subregion (e.g., the quantity of available project water supply declines), the model optimizes production by adjusting the crop mix, water sources and quantities used, and other inputs. The model also fallows land when that appears to be the most cost-effective response to resource conditions.

SWAP was used to compare the long-run agricultural economic responses to potential changes in CVP and SWP irrigation water delivery and to changes in groundwater conditions associated with the alternatives. Results from the surface water analysis that used the CalSim II model, as described in Chapter 5, Surface Water Resources and Water Supplies, were provided as inputs into SWAP through a standardized data linkage procedure. Results from the groundwater analysis that used the CVHM model, as described in Chapter 7, Groundwater Resources and Groundwater Quality, were used to develop changes in pumping lift in SWAP. SWAP produces estimates of the change in value and costs of agricultural production.

The analysis only reduces groundwater withdrawals based upon an optimization of agricultural production costs. The analysis does not restrict groundwater withdrawals based upon groundwater overdraft or groundwater quality conditions. As described in Chapter 7, Groundwater Resources and Groundwater Quality, the Sustainable Groundwater Management Act requires preparation of Groundwater Sustainability Plans (GSPs) by 2020 or 2022 for most of the groundwater basins in the Central Valley Region. The GSPs will identify methods to implement measures that will achieve sustainable groundwater operations by 2040 or 2042. The analysis in this chapter is focused on conditions that would occur in 2030. If local agencies fully implement GSPs prior to the regulatory deadline, increasing groundwater use would be less of an option for agricultural water users. However, to achieve sustainable conditions, some measures could require several years to design and construct new water supply facilities, and sustainable groundwater conditions are not required until the 2040s. Therefore, it was assumed that Central Valley agriculture water users would not reduce groundwater use by 2030, and that groundwater use would change in response to changes in CVP and SWP water supplies.

12.4.1.2 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 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 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 agricultural resources 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 agricultural resources 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.

12.4.2 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. However, the changes to agricultural resources 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.

12.4.2.1 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

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. 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 under the No Action Alternative and the Second Basis of Comparison. However, the CVP and SWP water deliveries would be less under the No Action Alternative as compared to the Second Basis of Comparison, as described in Chapter 5, Surface Water Resources and Water Supplies, which could result in more crop idling.

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 result in disruption of agricultural resources; however, the development of general plans includes preparation of environmental documentation that would identify methods to minimize adverse impacts to agricultural resources.

Under the No Action Alternative and the Second Basis of Comparison, development of future water resources management projects by 2030 which would result in improved water supply flexibility and availability, including water supplies for agricultural resources, as described in Chapter 3, Description of Alternatives.

By 2030 under the No Action Alternative and the Second Basis of Comparison, it is assumed that ongoing programs would result in restoration of more than 10,000 acres of intertidal and associated subtidal wetlands in Suisun Marsh and Cache Slough; and 17,000 to 20,000 acres of seasonal floodplain restoration in the Yolo Bypass. The restoration programs could disrupt agricultural resources depending upon the location of the restoration.

12.4.3 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, Revised Second Basis of Comparison, includes a comparison of the CalSim II model run results presented in this chapter and CalSim II model run results with the error corrected.

Chapter 7, Groundwater Resources and Groundwater Quality, 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.

The results of the impact analysis represents comparison of long-term changes that would occur between alternatives by 2030. The impact analysis does not represent short-term responses, especially during one to five years, in response to emergency flood or drought conditions.

12.4.3.1 No Action Alternative

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

12.4.3.1.1 Trinity River Region

Potential Changes in Irrigated Agricultural

There are no agricultural lands irrigated with CVP and SWP water supplies in the Trinity River Region. Therefore, there would be no changes in irrigated lands under the No Action Alternative as compared to the Second Basis of Comparison.

12.4.3.1.2 Central Valley Region

Potential Changes in Irrigated Agriculture.

Sacramento Valley

Results of the SWAP analysis indicated that agricultural crop patterns in the Sacramento Valley would be similar (less than 5 percent change) under the No Action Alternative and the Second Basis of Comparison over long-term average conditions and in dry and critical dry years, as summarized in Tables 12.16 and 12.17.

Table 12.16 Changes in Sacramento Valley Irrigated Acreage over the Long-term Average Conditions under the No Action Alternative as Compared to the Second Basis of Comparison

Crops	No Action Alternative (1000s acres)	Second Basis of Comparison (1000s acres)	Changes (1000s acres)
Grain Crops	155	154	1
Rice	548	548	0
Field Crops	59	59	0
Forage Crops	199	200	-1
Vegetables and Truck Crops	119	119	0
Orchards and Vineyards	456	457	0
Total	1,537	1,537	0

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.

Table 12.17 Changes in Sacramento Valley Irrigated Acreage in Dry and Critical Dry Years under the No Action Alternative as Compared to the Second Basis of Comparison

Crops	No Action Alternative (1000s acres)	Second Basis of Comparison (1000s acres)	Changes (1000s acres)
Grain Crops	155	155	0
Rice	544	548	-4
Field Crops	59	59	0
Forage Crops	197	198	-1

Crops	No Action Alternative (1000s acres)	Second Basis of Comparison (1000s acres)	Changes (1000s acres)
Vegetables and Truck Crops	119	119	0
Orchards and Vineyards	456	457	-1
Total	1,529	1,536	-7

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.

Agricultural production in the Sacramento Valley would be similar (less than 5 percent change) under the No Action Alternative and the Second Basis of Comparison over long-term average conditions and in dry and critical dry years due to increased use of groundwater, as summarized in Tables 12.18 and 12.19.

Table 12.18 Changes in Sacramento Valley Agricultural Production over the Long-term Average Conditions under the No Action Alternative as Compared to the Second Basis of Comparison

Crops	No Action Alternative ($ millions)	Second Basis of Comparison ($ millions)	Changes ($ millions)
Grain Crops	150	149	0.8
Rice	1,114	1,115	-0.9
Field Crops	77	77	0.1
Forage Crops	246	246	-0.7
Vegetables and Truck Crops	967	967	0.0
Orchards and Vineyards	3,192	3,193	-0.9
Total	5,745	5,747	-1.6

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.
All values of production are in 2012 dollar equivalent values.

Table 12.19 Changes in Sacramento Valley Agricultural Production in Dry and Critical Dry Years under the No Action Alternative as Compared to the Second Basis of Comparison

Crops	No Action Alternative ($ millions)	Second Basis of Comparison ($ millions)	Changes ($ millions)
Grain Crops	150	150	-0.5
Rice	1,107	1,114	-7.3

Crops	No Action Alternative ($ millions)	Second Basis of Comparison ($ millions)	Changes ($ millions)
Field Crops	77	77	-0.1
Forage Crops	243	245	-1.4
Vegetables and Truck Crops	967	967	-0.2
Orchards and Vineyards	3,191	3,193	-1.7
Total	5,735	5,746	-11.3

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.
All values of production are in 2012 dollar equivalent values.

San Joaquin Valley

Results of the SWAP analysis indicated that irrigated acreage in the San Joaquin Valley, including the Tulare Lake area, would be similar under the No Action Alternative as compared to the Second Basis of Comparison over long-term average conditions and in dry and critical dry years, as summarized in Tables 12.20 and 12.21.

Table 12.20 Changes in San Joaquin Valley Irrigated Acreage over the Long-term Average Conditions under the No Action Alternative as Compared to the Second Basis of Comparison

Crops	No Action Alternative (1000s acres)	Second Basis of Comparison (1000s acres)	Changes (1000s acres)
Grain Crops	1,024	1,024	0
Rice	17	17	0
Field Crops	828	828	0
Forage Crops	735	735	0
Vegetables and Truck Crops	633	633	0
Orchards and Vineyards	2,156	2,156	0
Total	5,392	5,392	0

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.

Table 12.21 Changes in San Joaquin Valley Irrigated Acreage in Dry and Critical Dry Years under the No Action Alternative as Compared to the Second Basis of Comparison

Crops	No Action Alternative (1000s acres)	Second Basis of Comparison (1000s acres)	Changes (1000s acres)
Grain Crops	1,010	1,024	-14
Rice	17	17	0
Field Crops	827	828	0
Forage Crops	735	735	-1
Vegetables and Truck Crops	633	633	0
Orchards and Vineyards	2,154	2,156	-2
Total	5,375	5,392	-17

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.

Agricultural production in the Sacramento Valley would be similar under the No Action Alternative and the Second Basis of Comparison over long-term average conditions and in dry and critical dry years due to increased use of groundwater, as summarized in Tables 12.22 and 12.23.

Table 12.22 Changes in San Joaquin Valley Agricultural Production over the Long-term Average Conditions under the No Action Alternative as Compared to the Second Basis of Comparison

Crops	No Action Alternative ($ millions)	Second Basis of Comparison ($ millions)	Changes ($ millions)
Grain Crops	1,373	1,373	-0.2
Rice	31	31	0.0
Field Crops	1,436	1,437	-0.4
Forage Crops	1,426	1,426	-0.1
Vegetables and Truck Crops	4,623	4,623	0.1
Orchards and Vineyards	16,547	16,547	0.0
Total	25,437	25,438	-0.5

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.
All values of production are in 2012 dollar equivalent values.

Table 12.23 Changes in San Joaquin Valley Agricultural Production in Dry and Critical Dry Years under the No Action Alternative as Compared to the Second Basis of Comparison

Crops	No Action Alternative ($ millions)	Second Basis of Comparison ($ millions)	Changes ($ millions)
Grain Crops	1,359	1,373	-14.4
Rice	31	31	0.0
Field Crops	1,436	1,437	-0.9
Forage Crops	1,426	1,426	-0.4
Vegetables and Truck Crops	4,623	4,623	-0.2
Orchards and Vineyards	16,542	16,547	-4.4
Total	25,417	25,437	-20.3

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.
All values of production are in 2012 dollar equivalent values.

Effects Related to Cross Delta Water Transfers

Potential effects to agricultural 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 agricultural resources were identified as reduced cultivation of agricultural lands over the term of the transfer in the seller's service area. However, the amount of land effected by the water transfers would be relatively small as compared to the total cultivated acreage within a region. Beneficial changes would occur related to agricultural resources in the purchaser's service areas. The analysis indicated that these potential impacts would not be substantial.

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.

12.4.3.1.3 San Francisco Bay Area, Central Coast, and Southern California Regions

Potential Changes in Irrigated Agricultural

It is anticipated that reductions in CVP and SWP water supplies within the San Francisco Bay Area, Central Coast, and Southern California regions would not result in reductions in irrigated acreage or land use changes due to the use of other water supplies in the same manner that is projected to occur in the Central Valley Region.

12.4.3.2 Alternative 1

Alternative 1 is identical to the Second Basis of Comparison. Alternative 1 is compared to the No Action Alternative and the Second Basis of Comparison. However, because agricultural resource conditions under Alternative 1 are identical to agricultural resource conditions under the Second Basis of Comparison; Alternative 1 is only compared to the No Action Alternative.

12.4.3.2.1 Alternative 1 Compared to the No Action Alternative

Trinity River Region

Potential Changes in Irrigated Agricultural

There are no agricultural lands irrigated with CVP and SWP water supplies in the Trinity River Region. Therefore, there would be no changes in irrigated lands under Alternative 1 as compared to the No Action Alternative.

Central Valley Region

Potential Changes in Irrigated Agricultural

Sacramento Valley

Results of the SWAP analysis indicated that agricultural crop patterns in the Sacramento Valley would be similar under Alternative 1 as compared to the No Action Alternative over long-term average conditions and in dry and critical dry years, as summarized in Tables 12.24 and 12.25.

Table 12.24 Changes in Sacramento Valley Irrigated Acreage over the Long-term Average Conditions under Alternative 1 as Compared to the No Action Alternative

Crops	Alternative 1 (1000s acres)	No Action Alternative (1000s acres)	Changes (1000s acres)
Grain Crops	154	155	-1
Rice	549	548	0
Field Crops	59	59	0
Forage Crops	200	199	1
Vegetables and Truck Crops	119	119	0
Orchards and Vineyards	457	456	0
Total	1,537	1,537	0

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.

Table 12.25 Changes in Sacramento Valley Irrigated Acreage in Dry and Critical Dry Years under Alternative 1 as Compared to the No Action Alternative

Crops	Alternative 1 (1000s acres)	No Action Alternative (1000s acres)	Changes (1000s acres)
Grain Crops	155	155	0
Rice	548	544	4
Field Crops	59	59	0
Forage Crops	198	197	1
Vegetables and Truck Crops	119	119	0
Orchards and Vineyards	457	456	1
Total	1,536	1,529	7

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.

Agricultural production in the Sacramento Valley would be similar (less than 5 percent change) under Alternative 1 as compared to the No Action Alternative over long-term average conditions and in dry and critical dry years due to reduced use of groundwater, as summarized in Tables 12.26 and 12.27.

Table 12.26 Changes in Sacramento Valley Agricultural Production over the Long-term Average Conditions under Alternative 1 as Compared to the No Action Alternative

Crops	Alternative 1 ($ millions)	No Action Alternative ($ millions)	Changes ($ millions)
Grain Crops	149	150	-0.8
Rice	1,115	1,114	0.9
Field Crops	77	77	-0.1
Forage Crops	246	246	0.7
Vegetables and Truck Crops	967	967	0.0
Orchards and Vineyards	3,193	3,192	0.9
Total	5,747	5,745	1.6

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.
All values of production are in 2012 dollar equivalent values.

Table 12.27 Changes in Sacramento Valley Agricultural Production in Dry and Critical Dry Years under Alternative 1 as Compared to the No Action Alternative

Crops	Alternative 1 ($ millions)	No Action Alternative ($ millions)	Changes ($ millions)
Grain Crops	150	150	0.5
Rice	1,114	1,107	7.3
Field Crops	77	77	0.1
Forage Crops	245	243	1.4
Vegetables and Truck Crops	967	967	0.2
Orchards and Vineyards	3,193	3,191	1.7
Total	5,746	5,735	11.3

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.
All values of production are in 2012 dollar equivalent values.

San Joaquin Valley

Results of the SWAP analysis indicated that irrigated acreage in the San Joaquin Valley, including the Tulare Lake area, would be similar under Alternative 1 as compared to the No Action Alternative over long-term average conditions and in dry and critical dry years, as summarized in Tables 12.28 and 12.29.

Table 12.28 Changes in San Joaquin Valley Irrigated Acreage over the Long-term Average Conditions under Alternative 1 as Compared to the No Action Alternative

Crops	Alternative 1 (1000s acres)	No Action Alternative (1000s acres)	Changes (1000s acres)
Grain Crops	1,024	1,024	0
Rice	17	17	0
Field Crops	828	828	0
Forage Crops	735	735	0
Vegetables and Truck Crops	633	633	0
Orchards and Vineyards	2,156	2,156	0
Total	5,392	5,392	0

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.

Table 12.29 Changes in San Joaquin Valley Irrigated Acreage in Dry and Critical Dry Years under Alternative 1 as Compared to the No Action Alternative

Crops	Alternative 1 (1000s acres)	No Action Alternative (1000s acres)	Changes (1000s acres)
Grain Crops	1,024	1,010	14
Rice	17	17	0
Field Crops	828	827	0
Forage Crops	735	735	1
Vegetables and Truck Crops	633	633	0
Orchards and Vineyards	2,156	2,154	2
Total	5,392	5,375	17

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.

Agricultural production in the San Joaquin Valley would be similar under Alternative 1 as compared to the No Action Alternative over long-term average conditions and in dry and critical dry years due to reduced use of groundwater, as summarized in Tables 12.30 and 12.31.

Table 12.30 Changes in San Joaquin Valley Agricultural Production over the Long-term Average Conditions under Alternative 1 as Compared to the No Action Alternative

Crops	Alternative 1 ($ millions)	No Action Alternative ($ millions)	Changes ($ millions)
Grain Crops	1,373	1,373	0.2
Rice	31	31	0.0
Field Crops	1,437	1,436	0.4
Forage Crops	1,426	1,426	0.1
Vegetables and Truck Crops	4,623	4,623	-0.1
Orchards and Vineyards	16,547	16,547	0.0
Total	25,438	25,437	0.5

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.
All values of production are in 2012 dollar equivalent values.

Table 12.31 Changes in San Joaquin Valley Agricultural Production in Dry and Critical Dry Years under Alternative 1 as Compared to the No Action Alternative

Crops	Alternative 1 ($ millions)	No Action Alternative ($ millions)	Changes ($ millions)
Grain Crops	1,373	1,359	14.4
Rice	31	31	0.0
Field Crops	1,437	1,436	0.9
Forage Crops	1,426	1,426	0.4
Vegetables and Truck Crops	4,623	4,623	0.2
Orchards and Vineyards	16,547	16,542	4.4
Total	25,437	25,417	20.3

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.
All values of production are in 2012 dollar equivalent values.

Effects Related to Water Transfers

Potential effects to agricultural 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 impacts on agricultural resources 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.

San Francisco Bay Area, Central Coast, and Southern California Regions

Potential Changes in Irrigated Agricultural

It is anticipated that reductions in CVP and SWP water supplies within the San Francisco Bay Area, Central Coast, and Southern California regions would not result in reductions in irrigated acreage or land use changes due to the use of other water supplies in the same manner that is projected to occur in the Central Valley Region.

12.4.3.2.2 Alternative 1 Compared to the Second Basis of Comparison

Alternative 1 is identical to the Second Basis of Comparison.

12.4.3.3 Alternative 2

The agricultural resources under Alternative 2 would identical to the conditions under the No Action Alternative; therefore, Alternative 2 is only compared to the Second Basis of Comparison.

12.4.3.3.1 Alternative 2 Compared to the Second Basis of Comparison

Changes to agricultural resources under Alternatives 2 as compared to the Second Basis of Comparison would be the same as the impacts described in Section 12.4.3.1, No Action Alternative.

12.4.3.4 Alternative 3

The CVP and SWP operations under Alternative 3 are similar to the Second Basis of Comparison with modified Old and Middle River flow criteria and New Melones Reservoir operations.

12.4.3.4.1 Alternative 3 Compared to the No Action Alternative

Trinity River Region

Potential Changes in Irrigated Agricultural

There are no agricultural lands irrigated with CVP and SWP water supplies in the Trinity River Region. Therefore, there would be no changes in irrigated lands under Alternative 3 as compared to the No Action Alternative.

Central Valley Region

Potential Changes in Irrigated Agricultural

Sacramento Valley

Results of the SWAP analysis indicated that agricultural crop patterns in the Sacramento Valley would be similar under Alternative 3 as compared to the No Action Alternative over long-term average conditions and in dry and critical dry years, as summarized in Tables 12.32 and 12.33.

Table 12.32 Changes in Sacramento Valley Irrigated Acreage over the Long-term Average Conditions under Alternative 3 as Compared to the No Action Alternative

Crops	Alternative 3 (1000s acres)	No Action Alternative (1000s acres)	Changes (1000s acres)
Grain Crops	154	155	-1
Rice	548	548	0
Field Crops	59	59	0
Forage Crops	200	199	1
Vegetables and Truck Crops	119	119	0

Crops	Alternative 3 (1000s acres)	No Action Alternative (1000s acres)	Changes (1000s acres)
Orchards and Vineyards	457	456	0
Total	1,537	1,537	0

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.

Table 12.33 Changes in Sacramento Valley Irrigated Acreage in Dry and Critical Dry Years under Alternative 3 as Compared to the No Action Alternative

Crops	Alternative 3 (1000s acres)	No Action Alternative (1000s acres)	Changes (1000s acres)
Grain Crops	155	155	0
Rice	547	544	3
Field Crops	59	59	0
Forage Crops	197	197	1
Vegetables and Truck Crops	119	119	0
Orchards and Vineyards	456	456	1
Total	1,533	1,529	4

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.

Agricultural production in the Sacramento Valley would be similar under Alternative 3 as compared to the No Action Alternative over long-term average conditions and in dry and critical dry years due to reduced use of groundwater, as summarized in Tables 12.34 and 12.35.

Table 12.34 Changes in Sacramento Valley Agricultural Production over the Long-term Average Conditions under Alternative 3 as Compared to the No Action Alternative

Crops	Alternative 3 ($ millions)	No Action Alternative ($ millions)	Changes ($ millions)
Grain Crops	149	150	-0.7
Rice	1,115	1,114	0.6
Field Crops	77	77	-0.1

Crops	Alternative 3 ($ millions)	No Action Alternative ($ millions)	Changes ($ millions)
Forage Crops	246	246	0.5
Vegetables and Truck Crops	967	967	0.0
Orchards and Vineyards	3,192	3,192	0.9
Total	5,746	5,745	1.2

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.
All values of production are in 2012 dollar equivalent values.

Table 12.35 Changes in Sacramento Valley Agricultural Production in Dry and Critical Dry Years under Alternative 3 as Compared to the No Action Alternative

Crops	Alternative 3 ($ millions)	No Action Alternative ($ millions)	Changes ($ millions)
Grain Crops	150	150	0.2
Rice	1,112	1,107	5.8
Field Crops	77	77	0.1
Forage Crops	244	243	0.8
Vegetables and Truck Crops	967	967	0.1
Orchards and Vineyards	3,193	3,191	2.2
Total	5,744	5,735	9.2

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.
All values of production are in 2012 dollar equivalent values.

San Joaquin Valley

Results of the SWAP analysis indicated that irrigated acreage in the San Joaquin Valley, including the Tulare Lake area, would be similar under Alternative 3 as compared to the No Action Alternative over long-term average conditions and in dry and critical dry years, as summarized in Tables 12.36 and 12.37.

Table 12.36 Changes in San Joaquin Valley Irrigated Acreage over the Long-term Average Conditions under Alternative 3 as Compared to the No Action Alternative

Crops	Alternative 3 (1000s acres)	No Action Alternative (1000s acres)	Changes (1000s acres)
Grain Crops	1,024	1,024	0
Rice	17	17	0
Field Crops	828	828	0
Forage Crops	735	735	0
Vegetables and Truck Crops	633	633	0
Orchards and Vineyards	2,156	2,156	0
Total	5,392	5,392	0

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.

Table 12.37 Changes in San Joaquin Valley Irrigated Acreage in Dry and Critical Dry Years under Alternative 3 as Compared to the No Action Alternative

Crops	Alternative 3 (1000s acres)	No Action Alternative (1000s acres)	Changes (1000s acres)
Grain Crops	1,021	1,010	11
Rice	17	17	0
Field Crops	828	827	0
Forage Crops	735	735	0
Vegetables and Truck Crops	633	633	0
Orchards and Vineyards	2,154	2,154	0
Total	5,387	5,375	12

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.

Agricultural production in the San Joaquin Valley would be similar under Alternative 3 as compared to the No Action Alternative over long-term average conditions and in dry and critical dry years due to reduced use of groundwater, as summarized in Tables 12.38 and 12.39.

Table 12.38 Changes in San Joaquin Valley Agricultural Production over the Long-term Average Conditions under Alternative 3 as Compared to the No Action Alternative

Crops	Alternative 3 ($ millions)	No Action Alternative ($ millions)	Changes ($ millions)
Grain Crops	1,373	1,373	0.1
Rice	31	31	0.0
Field Crops	1,437	1,436	0.3
Forage Crops	1,426	1,426	0.1
Vegetables and Truck Crops	4,623	4,623	-0.1
Orchards and Vineyards	16,547	16,547	-0.1
Total	25,437	25,437	0.3

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.
All values of production are in 2012 dollar equivalent values.

Table 12.39 Changes in San Joaquin Valley Agricultural Production in Dry and Critical Dry Years under Alternative 3 as Compared to the No Action Alternative

Crops	Alternative 3 ($ millions)	No Action Alternative ($ millions)	Changes ($ millions)
Grain Crops	1,370	1,359	11.5
Rice	31	31	0.0
Field Crops	1,436	1,436	0.4
Forage Crops	1,426	1,426	-0.1
Vegetables and Truck Crops	4,623	4,623	0.0
Orchards and Vineyards	16,542	16,542	-0.3
Total	25,428	25,417	11.4

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.
All values of production are in 2012 dollar equivalent values.

Effects Related to Water Transfers

Potential effects to agricultural 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 impacts on agricultural resources 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.

San Francisco Bay Area, Central Coast, and Southern California Regions

Potential Changes in Irrigated Agricultural

It is anticipated that reductions in CVP and SWP water supplies within the San Francisco Bay Area, Central Coast, and Southern California regions would not result in reductions in irrigated acreage or land use changes due to the use of other water supplies in the same manner that is projected to occur in the Central Valley Region.

12.4.3.4.2 Alternative 3 Compared to the Second Basis of Comparison

Trinity River Region

Potential Changes in Irrigated Agricultural

There are no agricultural lands irrigated with CVP and SWP water supplies in the Trinity River Region. Therefore, there would be no changes in irrigated lands under Alternative 3 as compared to the Second Basis of Comparison.

Central Valley Region

Potential Changes in Irrigated Agricultural

Sacramento Valley

Results of the SWAP analysis indicated that agricultural crop patterns in the Sacramento Valley would be similar under Alternative 3 as compared to the Second Basis of Comparison over long-term average conditions and in dry and critical dry years, as summarized in Tables 12.40 and 12.41.

Table 12.40 Changes in Sacramento Valley Irrigated Acreage over the Long-term Average Conditions under Alternative 3 as Compared to the Second Basis of Comparison

Crops	Alternative 3 (1000s acres)	Second Basis of Comparison (1000s acres)	Changes (1000s acres)
Grain Crops	154	154	0
Rice	548	548	0
Field Crops	59	59	0
Forage Crops	200	200	0
Vegetables and Truck Crops	119	119	0
Orchards and Vineyards	457	457	0
Total	1,537	1,537	0

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.

Table 12.41 Changes in Sacramento Valley Irrigated Acreage in Dry and Critical Dry Years under Alternative 3 as Compared to the Second Basis of Comparison

Crops	Alternative 3 (1000s acres)	Second Basis of Comparison (1000s acres)	Changes (1000s acres)
Grain Crops	155	155	0
Rice	547	548	-1
Field Crops	59	59	0
Forage Crops	197	198	-1
Vegetables and Truck Crops	119	119	0
Orchards and Vineyards	456	457	-1
Total	1,533	1,536	-3

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.

The agricultural production value under long-term average conditions and dry and critical dry conditions would be similar under Alternative 3 and Second Basis of Comparison, as summarized in Tables 12.42 and 12.43, primarily due to a decrease in groundwater pumping.

Table 12.42 Changes in Sacramento Valley Agricultural Production over the Long-term Average Conditions under Alternative 3 as Compared to the Second Basis of Comparison

Crops	Alternative 3 ($ millions)	Second Basis of Comparison ($ millions)	Changes ($ millions)
Grain Crops	149	149	0.1
Rice	1,115	1,115	-0.3
Field Crops	77	77	0.0
Forage Crops	246	246	-0.1
Vegetables and Truck Crops	967	967	0.0
Orchards and Vineyards	3,192	3,193	-0.1
Total	5,746	5,747	-0.3

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.
All values of production are in 2012 dollar equivalent values.

Table 12.43 Changes in Sacramento Valley Agricultural Production in Dry and Critical Dry Years under Alternative 3 as Compared to the Second Basis of Comparison

Crops	Alternative 3 ($ millions)	Second Basis of Comparison ($ millions)	Changes ($ millions)
Grain Crops	150	150	-0.3
Rice	1,112	1,114	-1.5
Field Crops	77	77	0.0
Forage Crops	244	245	-0.6
Vegetables and Truck Crops	967	967	-0.1
Orchards and Vineyards	3,193	3,193	0.4
Total	5,744	5,746	-2.1

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.
All values of production are in 2012 dollar equivalent values.

San Joaquin Valley

Results of the SWAP analysis indicated that irrigated acreage in the San Joaquin Valley, including the Tulare Lake area, would be similar under Alternative 3 as compared to the Second Basis of Comparison over long-term average conditions and in dry and critical dry years, as summarized in Tables 12.44 and 12.45.

Table 12.44 Changes in San Joaquin Valley Irrigated Acreage over the Long-term Average Conditions under Alternative 3 as Compared to the Second Basis of Comparison

Crops	Alternative 3 (1000s acres)	Second Basis of Comparison (1000s acres)	Changes (1000s acres)
Grain Crops	1,024	1,024	0
Rice	17	17	0
Field Crops	828	828	0
Forage Crops	735	735	0
Vegetables and Truck Crops	633	633	0
Orchards and Vineyards	2,156	2,156	0
Total	5,392	5,392	0

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.

Table 12.45 Changes in San Joaquin Valley Irrigated Acreage in Dry and Critical Dry Years under Alternative 3 as Compared to the Second Basis of Comparison

Crops	Alternative 3 (1000s acres)	Second Basis of Comparison (1000s acres)	Changes (1000s acres)
Grain Crops	1,021	1,024	-3
Rice	17	17	0
Field Crops	828	828	0
Forage Crops	735	735	-1
Vegetables and Truck Crops	633	633	0
Orchards and Vineyards	2,154	2,156	-2
Total	5,387	5,392	-5

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.

The agricultural production value under long-term average conditions would be similar under Alternative 3 and the Second Basis of Comparison, as summarized in Tables 12.46 and 12.47, primarily due to an increase in groundwater pumping.

Table 12.46 Changes in San Joaquin Valley Agricultural Production over the Long-term Average Conditions under Alternative 3 as Compared to the Second Basis of Comparison

Crops	Alternative 3 ($ millions)	Second Basis of Comparison ($ millions)	Changes ($ millions)
Grain Crops	1,373	1,373	-0.1
Rice	31	31	0.0
Field Crops	1,437	1,437	-0.1
Forage Crops	1,426	1,426	0.0
Vegetables and Truck Crops	4,623	4,623	0.0
Orchards and Vineyards	16,547	16,547	-0.1
Total	25,437	25,438	-0.3

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.
All values of production are in 2012 dollar equivalent values.

Table 12.47 Changes in San Joaquin Valley Agricultural Production in Dry and Critical Dry Years under Alternative 3 as Compared to the Second Basis of Comparison

Crops	Alternative 3 ($ millions)	Second Basis of Comparison ($ millions)	Changes ($ millions)
Grain Crops	1,370	1,373	-2.9
Rice	31	31	0.0
Field Crops	1,436	1,437	-0.6
Forage Crops	1,426	1,426	-0.5
Vegetables and Truck Crops	4,623	4,623	-0.2
Orchards and Vineyards	16,542	16,547	-4.7
Total	25,428	25,437	-8.9

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.
All values of production are in 2012 dollar equivalent values.

Effects Related to Water Transfers

It is anticipated that water would be transferred between subbasins in the same manner under Alternative 3 as compared to the Second Basis of Comparison. If the water to be transferred is made available through crop idling, there would be a reduction in irrigated acreage. If the water is used to reduce crop idling in dry and critical dry years, there would be an increase in irrigated acreage. Therefore, the changes in agricultural resources would need to be determined for each water transfer program.

Potential effects to agricultural 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 as compared to the Second Basis of Comparison, and that impacts on agricultural resources 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 as compared to the Second Basis of Comparison.

San Francisco Bay Area, Central Coast, and Southern California Regions

Potential Changes in Irrigated Agricultural

It is anticipated that reductions in CVP and SWP water supplies within the San Francisco Bay Area, Central Coast, and Southern California regions would not result in reductions in irrigated acreage or land use changes due to the use of other water supplies in the same manner that is projected to occur in the Central Valley Region.

12.4.3.5 Alternative 4

The agricultural resources 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.

12.4.3.5.1 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 agricultural resources 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.

12.4.3.6 Alternative 5

The 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.

12.4.3.6.1 Alternative 5 Compared to the No Action Alternative

Trinity River Region

Potential Changes in Irrigated Agricultural

There are no agricultural lands irrigated with CVP and SWP water supplies in the Trinity River Region. Therefore, there would be no changes in irrigated lands under Alternative 5 as compared to the No Action Alternative.

Central Valley Region

Potential Changes in Irrigated Agricultural

Sacramento Valley

Results of the SWAP analysis indicated that agricultural crop patterns in the Sacramento Valley would be similar under Alternative 5 as compared to the No Action Alternative over long-term average conditions and in dry and critical dry years, as summarized in Tables 12.48 and 12.49.

Table 12.48 Changes in Sacramento Valley Irrigated Acreage over the Long-term Average Conditions under Alternative 5 as Compared to the No Action Alternative

Crops	Alternative 5 (1000s acres)	No Action Alternative (1000s acres)	Changes (1000s acres)
Grain Crops	155	155	0
Rice	548	548	0
Field Crops	59	59	0
Forage Crops	199	199	0
Vegetables and Truck Crops	119	119	0
Orchards and Vineyards	456	456	0
Total	1,537	1,537	0

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.

Table 12.49 Changes in Sacramento Valley Irrigated Acreage in Dry and Critical Dry Years under Alternative 5 as Compared to the No Action Alternative

Crops	Alternative 5 (1000s acres)	No Action Alternative (1000s acres)	Changes (1000s acres)
Grain Crops	155	155	0
Rice	544	544	0
Field Crops	59	59	0
Forage Crops	197	197	0

Crops	Alternative 5 (1000s acres)	No Action Alternative (1000s acres)	Changes (1000s acres)
Vegetables and Truck Crops	119	119	0
Orchards and Vineyards	456	456	0
Total	1,529	1,529	0

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.

The agricultural production value under long-term average conditions and dry and critical dry conditions would be similar under Alternative 5 and the No Action Alternative, as summarized in Tables 12.50 and 12.51.

Table 12.50 Changes in Sacramento Valley Agricultural Production over the Long-term Average Conditions under Alternative 5 as Compared to the No Action Alternative

Crops	Alternative 5 ($ millions)	No Action Alternative ($ millions)	Changes ($ millions)
Grain Crops	150	150	0.0
Rice	1,114	1,114	0.1
Field Crops	77	77	0.0
Forage Crops	246	246	0.0
Vegetables and Truck Crops	967	967	0.0
Orchards and Vineyards	3,192	3,192	0.1
Total	5,745	5,745	0.1

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.
All values of production are in 2012 dollar equivalent values.

Table 12.51 Changes in Sacramento Valley Agricultural Production in Dry and Critical Dry Years under Alternative 5 as Compared to the No Action Alternative

Crops	Alternative 5 ($ millions)	No Action Alternative ($ millions)	Changes ($ millions)
Grain Crops	150	150	-0.1
Rice	1,107	1,107	0.2
Field Crops	77	77	0.0
Forage Crops	243	243	0.1
Vegetables and Truck Crops	967	967	0.0
Orchards and Vineyards	3,192	3,191	0.7
Total	5,736	5,735	0.8

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.
All values of production are in 2012 dollar equivalent values.

San Joaquin Valley

Results of the SWAP analysis indicated that irrigated acreage in the San Joaquin Valley, including the Tulare Lake area, would be similar under Alternative 5 as compared to the No Action Alternative over long-term average conditions and dry and critical dry years, as summarized in Tables 12.52 and 12.53.

Table 12.52 Changes in San Joaquin Valley Irrigated Acreage over the Long-term Average Conditions under Alternative 5 as Compared to the No Action Alternative

Crops	Alternative 5 (1000s acres)	No Action Alternative (1000s acres)	Changes (1000s acres)
Grain Crops	1,024	1,024	0
Rice	17	17	0
Field Crops	828	828	0
Forage Crops	735	735	0
Vegetables and Truck Crops	633	633	0
Orchards and Vineyards	2,156	2,156	0
Total	5,392	5,392	0

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.

Table 12.53 Changes in San Joaquin Valley Irrigated Acreage in Dry and Critical Dry Years under Alternative 5 as Compared to the No Action Alternative

Crops	Alternative 5 (1000s acres)	No Action Alternative (1000s acres)	Changes (1000s acres)
Grain Crops	1,010	1,010	0
Rice	17	17	0
Field Crops	827	827	0
Forage Crops	734	735	0
Vegetables and Truck Crops	633	633	0
Orchards and Vineyards	2,153	2,154	-1
Total	5,374	5,375	-1

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.

The agricultural production value under long-term average conditions and dry and critical dry year conditions would be similar under Alternative 5 and the No Action Alternative, as summarized in Tables 12.54 and 12.55.

Table 12.54 Changes in San Joaquin Valley Agricultural Production over the Long-term Average Conditions under Alternative 5 as Compared to the No Action Alternative

Crops	Alternative 5 ($ millions)	No Action Alternative ($ millions)	Changes ($ millions)
Grain Crops	1,373	1,373	0.0
Rice	31	31	0.0
Field Crops	1,436	1,436	0.0
Forage Crops	1,426	1,426	0.0
Vegetables and Truck Crops	4,623	4,623	0.0
Orchards and Vineyards	16,547	16,547	-0.1
Total	25,437	25,437	-0.1

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.
All values of production are in 2012 dollar equivalent values.

Table 12.55 Changes in San Joaquin Valley Agricultural Production in Dry and Critical Dry Years under Alternative 5 as Compared to the No Action Alternative

Crops	Alternative 5 ($ millions)	No Action Alternative ($ millions)	Changes ($ millions)
Grain Crops	1,359	1,359	-0.1
Rice	31	31	0.0
Field Crops	1,435	1,436	-0.2
Forage Crops	1,426	1,426	-0.1
Vegetables and Truck Crops	4,622	4,623	-0.2
Orchards and Vineyards	16,540	16,542	-2.0
Total	25,414	25,417	-2.7

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.
All values of production are in 2012 dollar equivalent values.

Effects Related to Water Transfers

Potential effects to agricultural 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 impacts on agricultural resources 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.

San Francisco Bay Area, Central Coast, and Southern California Regions

Potential Changes in Irrigated Agricultural

It is anticipated that reductions in CVP and SWP water supplies within the San Francisco Bay Area, Central Coast, and Southern California regions would not result in reductions in irrigated acreage or land use changes due to the use of other water supplies in the same manner that is projected to occur in the Central Valley Region.

12.4.3.6.2 Alternative 5 Compared to the Second Basis of Comparison

Trinity River Region

Potential Changes in Irrigated Agricultural

There are no agricultural lands irrigated with CVP and SWP water supplies in the Trinity River Region. Therefore, there would be no changes in irrigated lands under Alternative 5 as compared to the Second Basis of Comparison.

Central Valley Region

Potential Changes in Irrigated Agricultural

Sacramento Valley

Results of the SWAP analysis indicated that agricultural crop patterns in the Sacramento Valley would be similar under Alternative 5 as compared to the Second Basis of Comparison over long-term average conditions and in dry and critical dry years, as summarized in Tables 12.56 and 12.57.

Table 12.56 Changes in Sacramento Valley Irrigated Acreage over the Long-term Average Conditions under Alternative 5 as Compared to the Second Basis of Comparison

Crops	Alternative 5 (1000s acres)	Second Basis of Comparison (1000s acres)	Changes (1000s acres)
Grain Crops	155	154	1
Rice	548	549	0
Field Crops	59	59	0
Forage Crops	199	200	-1
Vegetables and Truck Crops	119	119	0
Orchards and Vineyards	456	457	0
Total	1,537	1,537	0

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.

Table 12.57 Changes in Sacramento Valley Irrigated Acreage in Dry and Critical Dry Years under Alternative 5 as Compared to the Second Basis of Comparison

Crops	Alternative 5 (1000s acres)	Second Basis of Comparison (1000s acres)	Changes (1000s acres)
Grain Crops	155	155	-1
Rice	544	548	-4
Field Crops	59	59	0

Crops	Alternative 5 (1000s acres)	Second Basis of Comparison (1000s acres)	Changes (1000s acres)
Forage Crops	197	198	-1
Vegetables and Truck Crops	119	119	0
Orchards and Vineyards	456	457	-1
Total	1,529	1,536	-7

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.

The agricultural production value under long-term average conditions and in dry and critical dry conditions would be similar under Alternative 5 and Second Basis of Comparison, as summarized in Tables 12.58 and 12.59.

Table 12.58 Changes in Sacramento Valley Agricultural Production over the Long-term Average Conditions under Alternative 5 as Compared to the Second Basis of Comparison

Crops	Alternative 5 ($ millions)	Second Basis of Comparison ($ millions)	Changes ($ millions)
Grain Crops	150	149	0.8
Rice	1,114	1,115	-0.8
Field Crops	77	77	0.1
Forage Crops	246	246	-0.6
Vegetables and Truck Crops	967	967	0.0
Orchards and Vineyards	3,192	3,193	-0.9
Total	5,745	5,747	-1.5

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.
All values of production are in 2012 dollar equivalent values.

Table 12.59 Changes in Sacramento Valley Agricultural Production in Dry and Critical Dry Years under Alternative 5 as Compared to the Second Basis of Comparison

Crops	Alternative 5 ($ millions)	Second Basis of Comparison ($ millions)	Changes ($ millions)
Grain Crops	150	150	-0.6
Rice	1,107	1,114	-7.1
Field Crops	77	77	-0.1
Forage Crops	243	245	-1.3
Vegetables and Truck Crops	967	967	-0.3
Orchards and Vineyards	3,192	3,193	-1.1
Total	5,736	5,746	-10.5

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.
All values of production are in 2012 dollar equivalent values.

San Joaquin Valley

Results of the SWAP analysis indicated that irrigated acreage in the San Joaquin Valley, including the Tulare Lake area, would be similar under Alternative 5 as compared to the Second Basis of Comparison over long-term average conditions and in dry and critical dry years, as summarized in Tables 12.60 and 12.61.

Table 12.60 Changes in San Joaquin Valley Irrigated Acreage over the Long-term Average Conditions under Alternative 5 as Compared to the Second Basis of Comparison

Crops	Alternative 5 (1000s acres)	Second Basis of Comparison (1000s acres)	Changes (1000s acres)
Grain Crops	1,024	1,024	0
Rice	17	17	0
Field Crops	828	828	0
Forage Crops	735	735	0
Vegetables and Truck Crops	633	633	0
Orchards and Vineyards	2,156	2,156	0
Total	5,392	5,392	-1

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.

Table 12.61 Changes in San Joaquin Valley Irrigated Acreage in Dry and Critical Dry Years under Alternative 5 as compared to the Second Basis of Comparison

Crops	Alternative 5 (1000s acres)	Second Basis of Comparison (1000s acres)	Changes (1000s acres)
Grain Crops	1,010	1,024	-14
Rice	17	17	0
Field Crops	827	828	0
Forage Crops	734	735	-1
Vegetables and Truck Crops	633	633	0
Orchards and Vineyards	2,153	2,156	-3
Total	5,374	5,392	-18

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.

The agricultural production value under long-term average conditions and in dry and critical dry conditions would be similar, as summarized in Tables 12.62 and 12.63, primarily due to an increase in groundwater pumping.

Table 12.62 Changes in San Joaquin Valley Agricultural Production over the Long-term Average Conditions under Alternative 5 as Compared to the Second Basis of Comparison

Crops	Alternative 5 ($ millions)	Second Basis of Comparison ($ millions)	Changes ($ millions)
Grain Crops	1,373	1,373	-0.2
Rice	31	31	0.0
Field Crops	1,436	1,437	-0.5
Forage Crops	1,426	1,426	-0.1
Vegetables and Truck Crops	4,623	4,623	0.2
Orchards and Vineyards	16,547	16,547	-0.1
Total	25,437	25,438	-0.7

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.
All values of production are in 2012 dollar equivalent values.

Table 12.63 Changes in San Joaquin Valley Agricultural Production in Dry and Critical Dry Years under Alternative 5 as Compared to the Second Basis of Comparison

Crops	Alternative 5 ($ millions)	Second Basis of Comparison ($ millions)	Changes ($ millions)
Grain Crops	1,359	1,373	-14.5
Rice	31	31	0.0
Field Crops	1,435	1,437	-1.2
Forage Crops	1,426	1,426	-0.5
Vegetables and Truck Crops	4,622	4,623	-0.5
Orchards and Vineyards	16,540	16,547	-6.4
Total	25,414	25,437	-22.9

Notes:
Grain crops include corn, dry beans, and grain.
Field crops include cotton, grass, hay, safflower, and sugar beets.
Forage crops include alfalfa and pasture.
All values of production are in 2012 dollar equivalent values.

Effects Related to Water Transfers

Potential effects to agricultural 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 impacts on agricultural resources 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 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.

San Francisco Bay Area, Central Coast, and Southern California Regions

Potential Changes in Irrigated Agricultural

It is anticipated that reductions in CVP and SWP water supplies within the San Francisco Bay Area, Central Coast, and Southern California regions would not result in reductions in irrigated acreage or land use changes due to the use of other water supplies in the same manner that is projected to occur in the Central Valley Region.

12.4.3.7 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 12.64 and 12.65. The results of the impact analysis represents comparison of long-term changes that would occur between alternatives by 2030. The impact analysis does not represent short-term responses, especially during one to five years, in response to emergency flood or drought conditions.

Table 12.64 Comparison of Alternatives 1 through 5 to No Action Alternative

Alternative	Potential Change	Consideration for Mitigation Measures
Alternative 1	No effects on agricultural resources.	None needed
Alternative 2	No effects on agricultural resources.	None needed
Alternative 3	No effects on agricultural resources.	None needed
Alternative 4	No effects on agricultural resources.	None needed
Alternative 5	No effects on agricultural resources.	None needed

Table 12.65 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	No effects on agricultural resources.	Not considered for this comparison.
Alternative 1	No effects on agricultural resources.	Not considered for this comparison.
Alternative 2	No effects on agricultural resources.	Not considered for this comparison.
Alternative 3	No effects on agricultural resources.	Not considered for this comparison.
Alternative 4	No effects on agricultural resources.	Not considered for this comparison.
Alternative 5	No effects on agricultural resources.	Not considered for this comparison.

12.4.3.8 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.

Changes in CVP and SWP operations under Alternatives 1 through 5 as compared to the No Action Alternative, would not result in changes in agricultural resources. Therefore, there would be no adverse impacts to agricultural resources; and no mitigation measures are required.

12.4.3.9 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 Agricultural Resources are summarized in Table 12.66.

Table 12.66 Summary of Cumulative Effects on Agricultural 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 and in All Alternatives in Year 2030	Consistent with Affected Environment conditions plus: 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 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): - 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 - General plans for 2030. - Trinity River Restoration Program. - Central Valley Project Improvement Act programs - Iron Mountain Mine Superfund Site - Nimbus Fish Hatchery Fish Passage Project - Folsom Dam Water Control Manual Update - FERC Relicensing for the Middle Fork of the American River Project - Lower Mokelumne River Spawning Habitat Improvement Project - Dutch Slough Tidal Marsh Restoration	<u>These effects would be the same under all alternatives.</u> 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 as compared to past conditions. Some future water quality and habitat projects could modify surface water conditions; however, water supplies are not anticipated to be affected. Future water supply projects are anticipated to both increase water supply reliability due to reduced 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. Developments under the general plans and future water supply, water quality improvement, and restoration projects are anticipated to potentially affect agricultural resources. However, development of these future programs would include preparation of environmental documentation that would identify methods to minimize adverse impacts to agricultural resources.

Scenarios	Actions	Cumulative Effects of Actions
	- Suisun Marsh Habitat Management, Preservation, and Restoration Plan Implementation - Tidal Wetland Restoration: Yolo Ranch, Northern Liberty Island Fish Restoration Project, Prospect Island Restoration Project, and Calhoun Cut/Lindsey Slough Tidal Habitat Restoration Project - San Joaquin River Restoration Program - Stockton Deep Water Ship Channel Dissolved Oxygen Project - Grasslands Bypass Project - Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS) - 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 remaining agricultural resources.
Future Actions considered as Cumulative Effects Actions with All Alternatives in Year 2030	Actions as described in Section 3.5 (of Chapter 3, Descriptions of Alternatives): - Bay-Delta Water Quality Control Plan Update - FERC Relicensing Projects - Bay Delta Conservation Plan (including the California WaterFix alternative) - Shasta Lake Water Resources, North-of-the-Delta Offstream Storage, Los Vaqueros Reservoir Expansion Phase 2, and Upper San Joaquin River Basin Storage Investigations - El Dorado Water and Power Authority Supplemental Water Rights Project - Sacramento River Water Reliability Project - Semitropic Water Storage District Delta Wetlands - North Bay Aqueduct Alternative Intake - Irrigated Lands Regulatory Program - San Luis Reservoir Low Point Improvement Project - *Westlands Water District v. United States Settlement* - Future water supply projects, including water recycling,	<u>These effects would be the same under all alternatives.</u> Most of the 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. Some of the 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. Developments under the future projects are anticipated to potentially affect agricultural resources. However, development of these future programs would include preparation of environmental documentation that would identify methods to minimize adverse impacts to agricultural resources. Some of the 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

Scenarios	Actions	Cumulative Effects of Actions
	desalination, groundwater banks and wellfields, and conveyance facilities (projects that did not have completed environmental documents during preparation of the EIS)	beneficial impact to agricultural resources.
No Action Alternative with Associated Cumulative Effects Actions in Year 2030	Full implementation of the 2008 USFWS BO and 2009 NMFS BO	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. Future water supply projects are anticipated to both increase water supply reliability due to reduced surface water supplies and to accommodate planned growth in the general plans. Some of the reasonably foreseeable actions would reduce the effects of agricultural drainage and/or reduce salinity in the San Joaquin River and the Delta.
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 reasonably foreseeable actions would result in similar changes as under the No Action Alternative with the added 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 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 similar changes 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) Slight increase in positive Old and Middle River flows in the winter and spring months	Implementation of Alternative 3 with reasonably foreseeable actions would result in similar changes as under the No Action Alternative with the added actions.
Alternative 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 Alternative 4 with reasonably foreseeable actions would result in similar changes as under the No Action Alternative with the added actions.
Alternative 5 with Associated Cumulative Effects Actions in Year 20530	Full implementation of the 2008 USFWS BO and 2009 NMFS BO 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 changes as under the No Action Alternative with the added actions.

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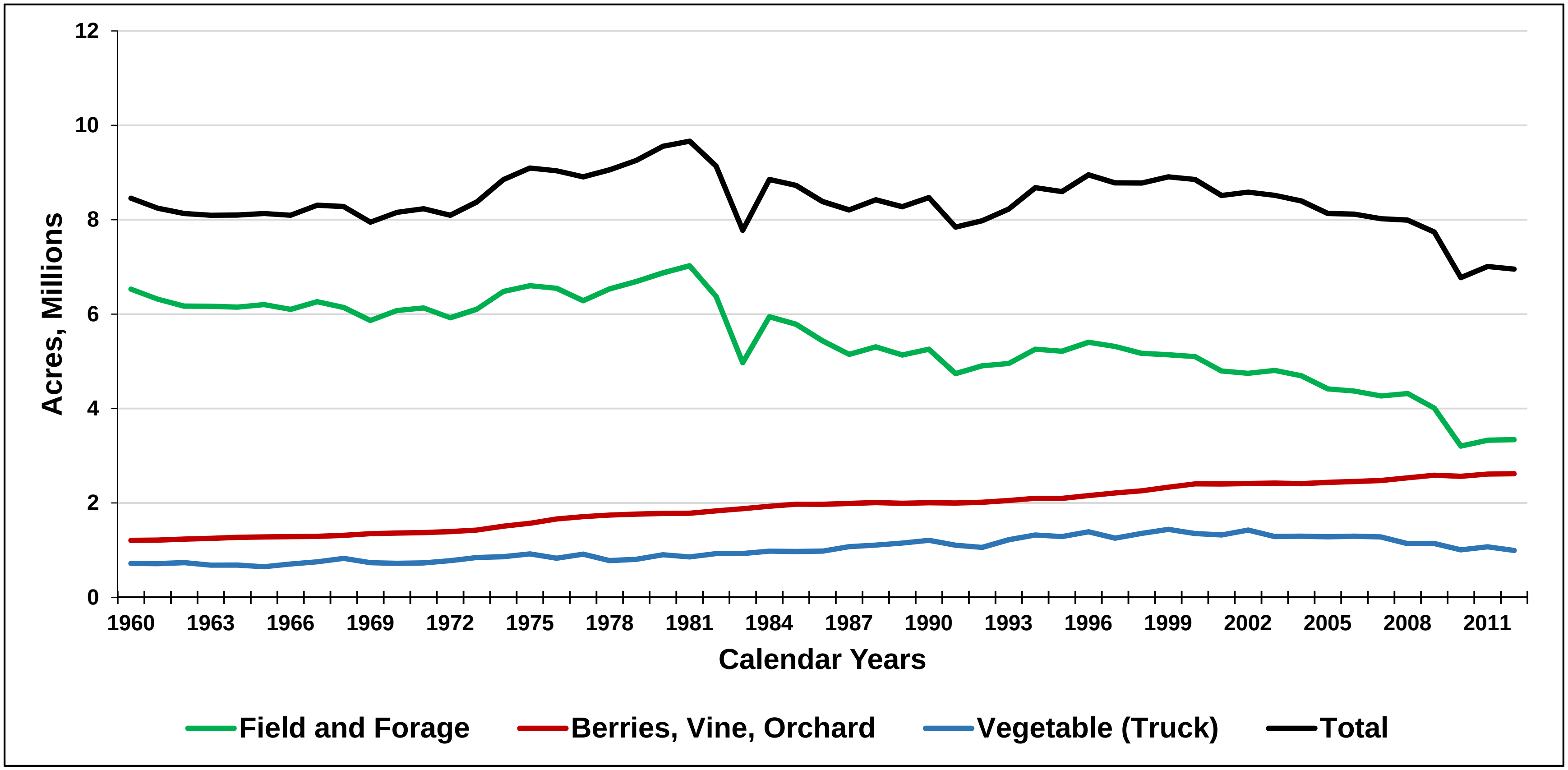

Figure 12.1 California Agricultural Production Acreage, 1960 to 2012

Source: USDA-NASS 2011, 2012a, 2012b, 2013b

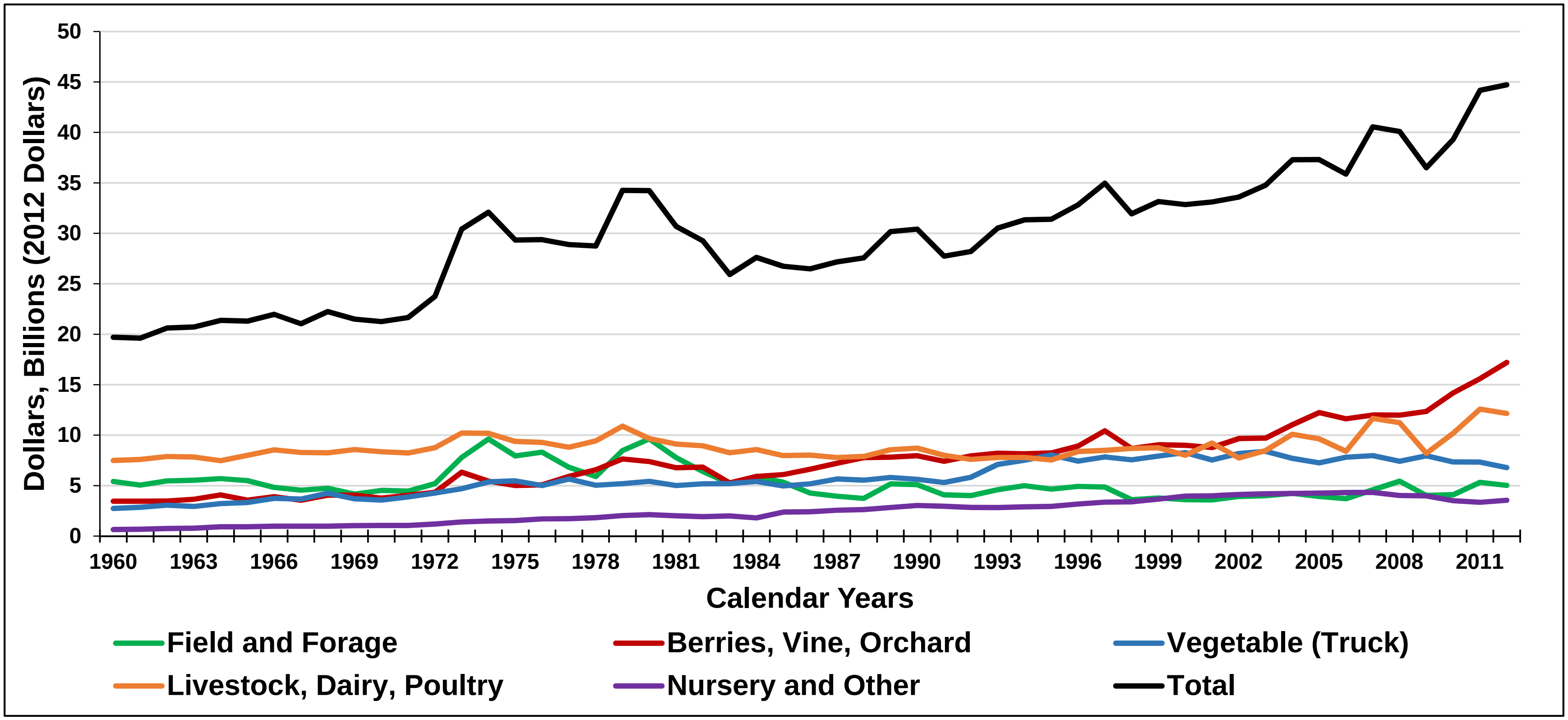

Figure 12.2 Total Value of California Agricultural Production, 1960 to 2012

Source: USDA 2014b; USDA-NASS 2008, 2009, 2010, 2011a, 2011b, 2012a, 2012b, 2013a, 2013b

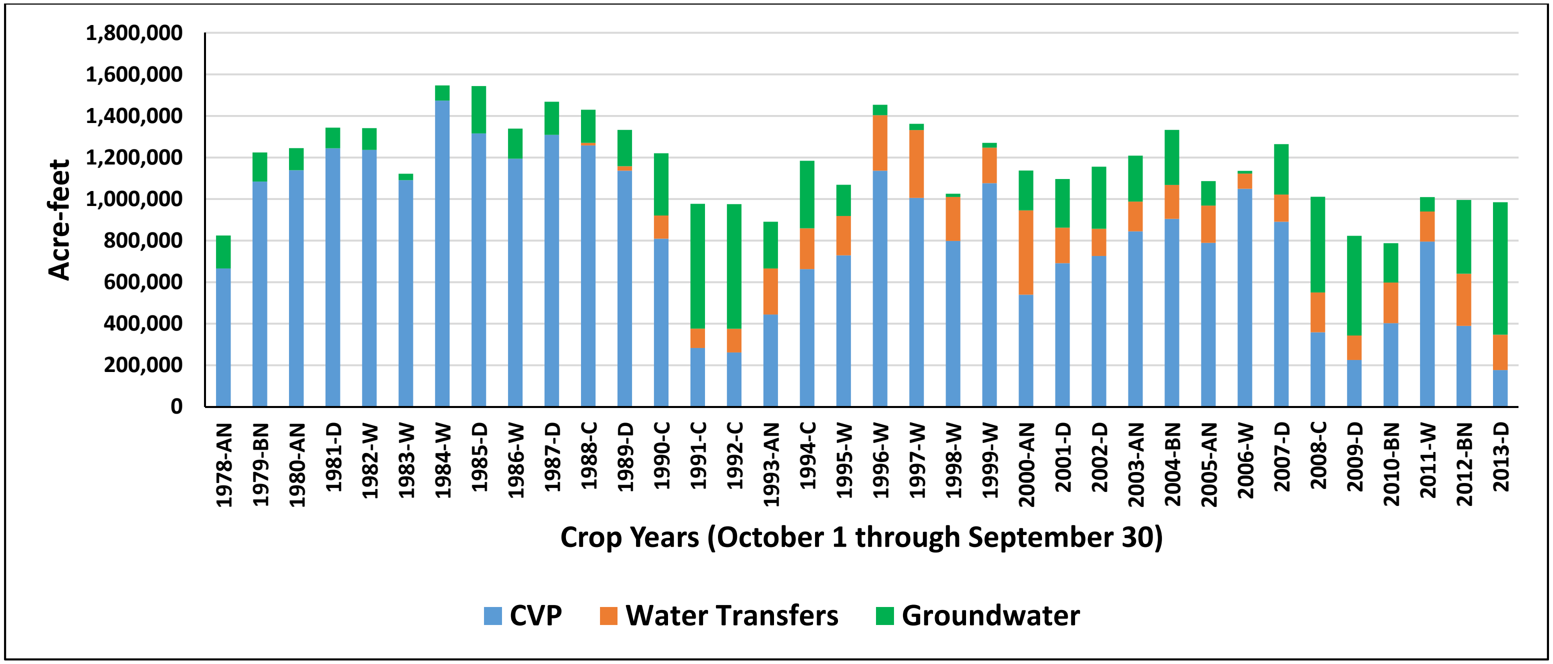

Figure 12.3 Historical Surface Water and Groundwater Supply Sources in Westlands Water District

W = Wet Year; AN= Above Normal Year; BN = Below Normal Year; D = Dry Year; C = Critical Dry Year

Source: WWD 2013a, 2014a

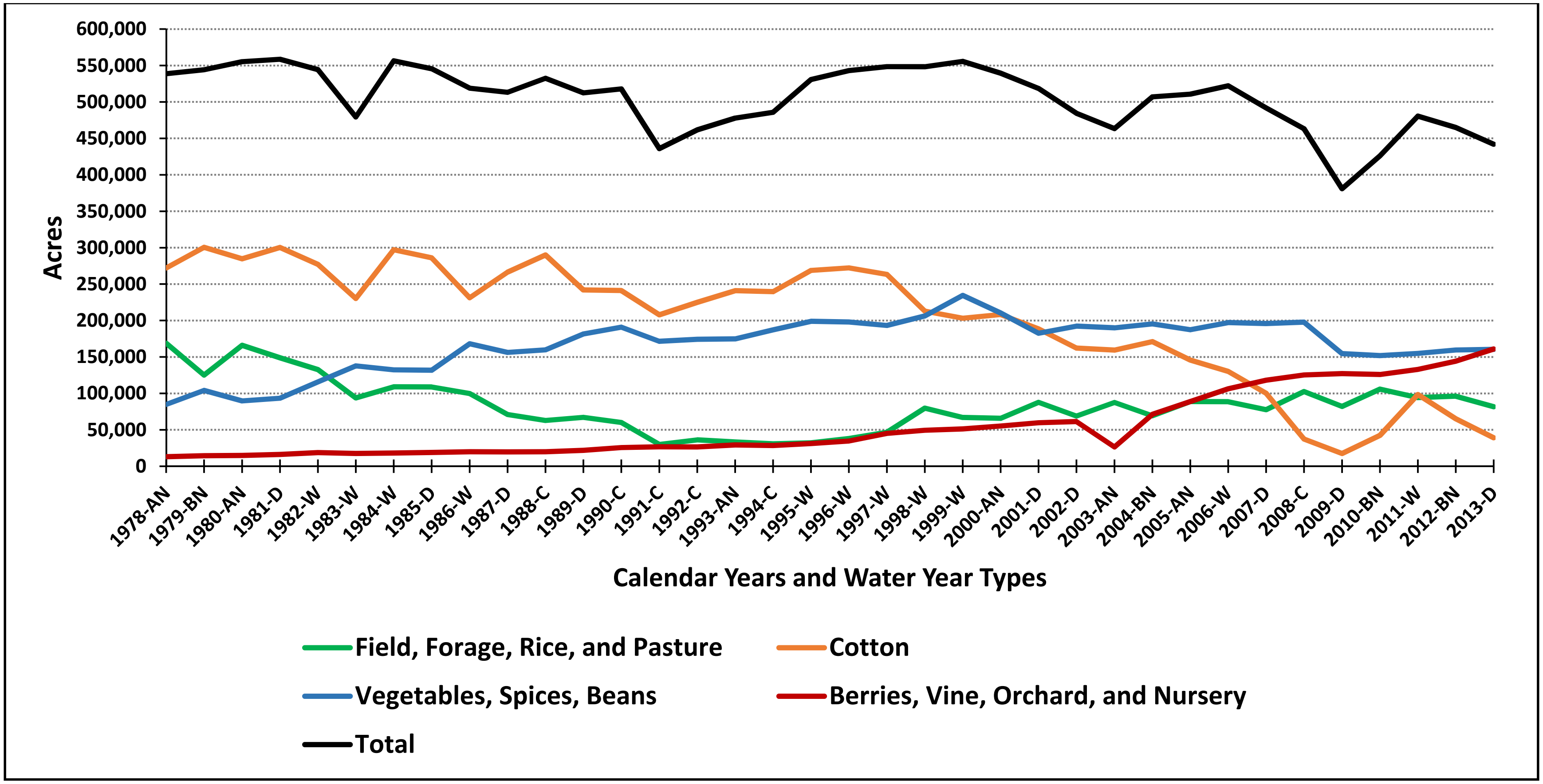

Figure 12.4 Historical Cropping Patterns in Westlands Water District

W = Wet Year; AN= Above Normal Year; BN = Below Normal Year; D = Dry Year; C = Critical Dry Year

Source: WWD 2013a, 2014b, 2014c

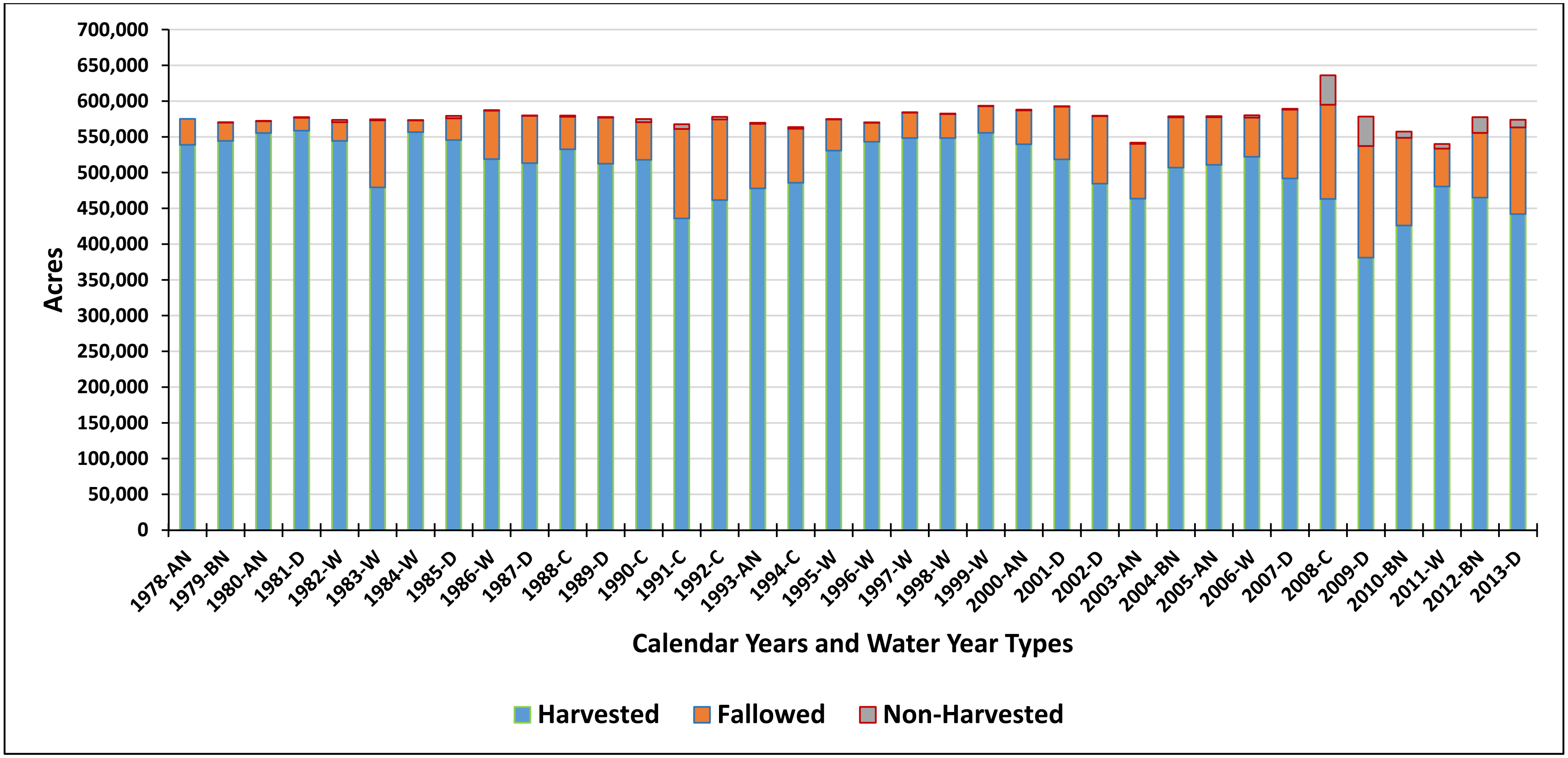

Figure 12.5 Historical Harvested, Fallowed, and Non-Harvested Acreage in Westlands Water District

W = Wet Year; AN= Above Normal Year; BN = Below Normal Year; D = Dry Year; C = Critical Dry Year

Source: WWD 2013a, 2014b, 2014c

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Chapter 13

Land Use

13.1 Introduction

This chapter describes non-agricultural land use 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 municipal and industrial land uses through potential changes in the Central Valley Project (CVP) and State Water Project (SWP) operation.

Changes in agricultural land use and resources are described in Chapter 12, Agricultural Resources. Changes to population are described in Chapter 19, Socioeconomics.

13.2 Regulatory Environment and Compliance Requirements

Potential actions that could be implemented under the alternatives evaluated in this EIS could affect land uses served by CVP and SWP water supplies. Actions done 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 (summarized in Chapter 4, Approach to Environmental Analysis).

13.3 Affected Environment

This section describes land use conditions potentially affected by the implementation of the alternatives considered in this EIS. Changes in land uses from changes in CVP and SWP operations may occur in the Trinity River, Central Valley, San Francisco Bay Area, Central Coast, and Southern California regions.

An extensive range of land uses are within this study area. However, direct or indirect land use effects from implementing the alternatives analyzed in this EIS are related to changes in agricultural, municipal, and industrial land uses from the availability and reliability of CVP and SWP water supplies. The following description of the affected environment is presented at the county-level for agricultural and municipal and industrial land uses. More detailed agricultural land use information is presented in Chapter 12, Agricultural Resources.

13.3.1 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. Tribal lands are also included for the entire Trinity River Region.

13.3.1.1 Trinity County

Trinity County encompasses approximately 3,206 square miles in northwestern California. It is bounded on the north by Siskiyou County, on the east by Shasta and Tehama Counties, on the south by Mendocino County, and on the west by Humboldt County. About 76 percent of the land area is within a national forest (Shasta-Trinity, Six Rivers, and Mendocino) and in four wilderness areas (Yolla Bolly-Middle Eel Reserve, Trinity Alps, Chanchellula, and North Fork). Another 14 percent is zoned for timber use or held in agriculture land conservation contracts (Trinity County 2012).

The headwaters of the Trinity River are in the northeastern part of the County at an elevation of 6,200 feet, in the southern Siskiyou Mountains. Trinity Lake and Lewiston Reservoir are located along the middle reach of the mainstem Trinity River. Downstream of Lewiston Dam, the river flows northwest to join the Klamath River in Humboldt County (Trinity County 2012).

Development of communities is relatively limited in Trinity County because much of the land is within national forests and tribal lands or is characterized by steep slopes. The largest communities in Trinity County include Lewiston, Weaverville, and Hayfork (Trinity County 2012).

Trinity County’s primary industries are tourism and timber and is the sixth largest timber producer in the state, with substantial acreage in National Forest and private holdings. There is one operating mill in the County. Recreational opportunities are also important in this area, as described in Chapter 15, Recreation Resources (Trinity County 2012).

The portion of Trinity County in the Trinity River Region that could be affected by changes in CVP and/or SWP operations and evaluated in this EIS includes areas in the vicinity of CVP facilities (Trinity Lake and Lewiston Reservoir) and areas along the Trinity River that use the river.

13.3.1.2 Humboldt County

Humboldt County encompasses approximately 3,570 square miles in northwestern California. It is bounded on the north by Del Norte County, on the east by Siskiyou and Trinity counties, on the south by Mendocino County, and on the west by the Pacific Ocean. About 25 percent of the land area is within the Six Rivers National Forest, Trinity Alps Wilderness Area, Redwood National and State National Park, national wildlife refuges, or other public land. About 3 percent of the land area is within state park lands. The Yurok and Hoopa tribal lands represent about 5.6 percent of the land within Humboldt County boundaries (Humboldt County 2012).

Most of the population and developed areas are located in western Humboldt County along U.S. Highway 101 (Humboldt County 2012). Incorporated cities and residential lands in unincorporated portions of Humboldt County represent less than 1 percent of the county. Development of communities is relatively limited in Humboldt County because much of the land is within national forests and tribal lands, characterized by steep slopes, or within the coastal zone where new large scale developments are minimized. Timber and agricultural lands are located on over 60 percent of unincorporated areas of Humboldt County.

Humboldt County's primary industries are lumber manufacturing, retail, and services (Humboldt County 2012). Humboldt County provides over 25 percent of the lumber in the state.

The portion of Humboldt County in the Trinity River Region evaluated in this EIS is located along the Trinity and Klamath rivers. Most of this area is located within the Hoopa Valley Indian Reservation and Yurok Indian Reservation. This portion of the county includes the communities of Willow Creek and Orleans within Humboldt County; Hoopa in the Hoopa Valley Indian Reservation; and the communities of Weitchpec, Cappell, Pecwan, and Johnson's in the Yurok Tribe Indian Reservation (Humboldt County 2012).

13.3.1.3 Del Norte County

Del Norte County encompasses 1,070 square miles in northwestern California. It is bounded on the north by the State of Oregon, on the east by Siskiyou County, on the south by Humboldt County, and on the west by the Pacific Ocean. Del Norte County includes lands within national forests (Six Rivers and Rogue River-Siskiyou), Smith River National Recreation Area, Redwood National and State Park, or other federally owned land. State lands include units of the Redwoods State Park and the Lake Earl Wildlife Area. The Yurok tribal lands are located along the lower Klamath River between the Del Norte and Humboldt county boundaries to the Pacific Ocean (Del Norte County 2003).

Del Norte County's primary industries are retail and services (Del Norte County 2003).

The portion of Del Norte County in the Trinity River Region evaluated in this EIS is located along the lower Klamath River. Most of this area is within the Yurok Indian Reservation. This portion of the County includes the communities of Requa and Klamath in the Yurok Tribe Indian Reservation (Del Norte County 2003).

13.3.1.4 Tribal Lands in Trinity River Region

The major federally recognized tribes and tribal lands in the Trinity River Region include the tribal lands of the Hoopa Valley Tribe, Yurok Tribe of the Yurok Reservation, Resighini Rancheria, and Karuk Tribe. Aquatic and wildlife resources associated with the Trinity and Klamath rivers and the surrounding lands are very important to these tribes (NCRWQCB et al. 2009; Yurok Tribe 2005; Karuk Tribe 2010).

The Hoopa Valley Indian Reservation includes 93,702.73 acres (Hoopa Valley Tribe 2008). The Trinity River flows through the Hoopa Valley Indian Reservation.

The Yurok Indian Reservation includes about 55,890 acres within Tribal trust, Tribal fee, allotment, Tribal member fee, nonmember fee, Federal, state, and county lands (Yurok Tribe 2012). The Tribe employs over 250 in the government agency, as well as seasonal workers for fisheries, forestry, fire prevention, and other programs.

The Resighini Rancheria includes about 435 acres of land along the south bank of the lower Klamath River and extends from an inland area to the U.S. Highway 101 bridge along the western boundary of the Rancheria (Reclamation 2010). The Rancheria is surrounded by the Yurok Indian Reservation (Reclamation 2010; Resighini Rancheria 2014). The community includes tribal offices, a casino, campground, residences, agricultural lands, and open space.

The Karuk Ancestral Territory is located to the north of the Trinity River in the vicinity of Trinity County and east of the Trinity River in the vicinity of Humboldt County (Karuk Tribe 2010). The western boundary of the Karuk Ancestral Territory is relatively concurrent with the western boundary of the Six Rivers National Forest. Therefore, changes in the Trinity River flow or water quality that could be affected by changes in CVP and/or SWP operations considered in the alternatives in this EIS would not occur within the Karuk Ancestral Territory.

13.3.2 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.

13.3.2.1 Sacramento Valley

The Sacramento Valley includes the counties of Shasta, Plumas, Tehama, Glenn, Colusa, Butte, Sutter, Yuba, Nevada, Placer, El Dorado, and Sacramento counties. Yolo and Solano counties are also located within the Sacramento Valley; however, these counties are discussed as part of the Delta and Suisun Marsh subsection because potential changes in land use because of changes in CVP and SWP long-term operations would primarily occur within the Delta and Suisun marsh geography. Other counties in this region are not anticipated to be affected by changes in CVP and SWP operations, and are not discussed here, including: Alpine, Sierra, Lassen, and Amador counties. Tribal lands are also described for the entire Sacramento Valley.

13.3.2.1.1 Shasta County

Shasta County encompasses approximately 3,793 square miles in northern California. It is bounded on the north by Siskiyou County, on the east by Lassen County, on the south by Tehama County, and on the west by Trinity County. Shasta County includes lands within national forests (Shasta-Trinity, Whiskeytown-Shasta-Trinity, and Lassen), Lassen Volcanic National Park, or other federally owned land. State lands include state forest and state parks (Shasta County 2004).

The Shasta County General Plan identifies four major categories of land use: urban, rural, agricultural, and timber (Shasta County 2004). Of Shasta County's 2,416,440 acres, 613,495 acres (25 percent) are designated as timber preserve zones pursuant to California's Forest Taxation Reform Act of 1976 (Shasta County 2004). Approximately 169,127 acres (7 percent), are designated as agricultural preserve lands.

Approximately 1.2 percent of the lands in the County are within incorporated areas (Shasta County 2004). Urban development is concentrated in the southern central portion of the county in the cities of Redding, Anderson, and Shasta Lake (Reclamation 2005a).

The portion of the Central Valley Region, Sacramento Valley in Shasta County that could be affected by changes in CVP and/or SWP operations and evaluated in this EIS includes CVP facilities (Shasta Lake, Keswick Reservoir, and Whiskeytown Lake), areas along the Sacramento River and Clear Creek that use the surface waters (including agricultural lands), and CVP water service areas.

13.3.2.1.2 Plumas County

Plumas County encompasses approximately 2,610 square miles in northern California. It is bounded on the north by Shasta County, on the east by Lassen County, on the west by Tehama and Butte counties, and on the south by Sierra County. Plumas County includes lands within national forests (Plumas, Lassen, Toiyabe, and Tahoe), Lassen Volcanic National Park, or other federally owned land. State lands include Plumas-Eureka State Park (Plumas County 2012).

Prominent landscape features in Plumas County are the Sierra Valley, the Lake Almanor Basin, and the Upper Feather River watershed which includes three SWP lakes (Antelope Lake, Lake Davis, and Frenchman Lake). The largest land uses in the county are agricultural and timber resource lands. Rural and semi-rural development is scattered throughout the County, with most growth concentrated in several designated planning areas. The county’s only incorporated area is the City of Portola.

The most recent Plumas County General Plan was adopted in 1984. The county is in the process of updating its General Plan through 2030 (Plumas County 2012). Approximately 76 percent of the land in Plumas County is National Forest land owned and managed by the U.S. Forest Service. The U.S. Forest Service prepared the Plumas National Forest Land and Resource Management Plan in 1988, to guide management and land use planning decisions in the forest. The National Forest Land and Resource Management Plan provides a designation for areas based on established priorities for various resources, including wilderness, recreation, wildlife, timber, and visual resources (Plumas County 2012).

The portion of the Central Valley Region, Sacramento Valley in Plumas County that could be affected by changes in CVP and/or SWP operations and evaluated in this EIS is located at the SWP Antelope Lake, Lake Davis, and Frenchman Lake and along the Feather River downstream of Frenchman Lake.

13.3.2.1.3 Tehama County

Tehama County encompasses approximately 2,951 square miles in northern California. It is bounded on the north by Shasta County, on the east by Plumas County, on the west by Trinity and Mendocino counties, and on the south by Glenn and Butte counties. Tehama County includes lands within national forests (Lassen, Mendocino, and Shasta-Trinity), Lassen Volcanic National Park, or other federally owned land (Tehama County 2008).

Tehama County is predominantly rural, with populations primarily concentrated in the incorporated cities of Corning, Red Bluff, and Tehama or along the major transportation corridors. The incorporated areas include less than 1 percent of the total land area in the county. The primary incorporated and unincorporated developed areas in the county are adjacent to major transportation centers, with most adjacent to Interstate 5 and State Route 99. Clustered commercial land uses are located primarily along the major state and county roadways, most of which are near Red Bluff, Corning, and the unincorporated community of Los Molinos. Residential land uses in the developed portions of the county tend to be located behind or beyond the commercial and service uses adjacent to the major street network (Tehama County 2008).

Ranches, timber company holdings, and government land dominate the county. Much of the land use is resource-based, such as cropland, rangeland, pasture land, and timber land (Tehama County 2008). The majority of land within the CVP water service area in Tehama County is designated for agricultural use (Tehama County 2008; Reclamation 2005b).

The portion of the Central Valley Region, Sacramento Valley in Tehama County that could be affected by changes in CVP and/or SWP operations and evaluated in this EIS includes CVP facilities, areas along the Sacramento River that use the surface waters (including agricultural lands), and CVP water service areas.

13.3.2.1.4 Glenn County

Glenn County encompasses 1,317 square miles in northern California. It is bounded on the north by Tehama County, on the east by Butte County, on the west by Lake and Mendocino counties, and on the south by Colusa County. Glenn County includes lands within the Mendocino National Forest, Sacramento National Wildlife Refuge, and other federally owned land (Glenn County 1993).

Approximately two-thirds (583,974 acres) are croplands and pasture. The two incorporated towns in the county are Willows, the County seat, and Orland (Reclamation 2004). Intensive agriculture provides a major segment of the county’s economic base (Glenn County 1993; Reclamation 2005b).The portion of the Central Valley Region, Sacramento Valley in Glenn County that could be affected by changes in CVP and/or SWP operations and evaluated in this EIS includes wildlife refuges (described in Chapter 10, Terrestrial Biological Resources), and CVP facilities, areas along the Sacramento River that use the surface waters (including agricultural lands), and CVP water service areas.

13.3.2.1.5 Colusa County

Colusa County encompasses approximately 1,132 square miles in northern California. It is bounded on the north by Glenn County, on the east by Butte and Sutter counties, on the west by Lake County, and on the south by Yolo County. Colusa County includes lands within the Mendocino National Forest, Sacramento National Wildlife Refuge complex (Colusa, Delevan, and Sacramento national wildlife refuges); East Park Reservoir; and other federally owned land (Colusa County 2011). State lands in Colusa County include Willow Creek-Lurline, North Central Valley, Colusa Bypass, and Sacramento River wildlife management areas.

Existing land uses in Colusa County are predominantly agricultural. Approximately 76 percent of the county's total land area is cropland or undeveloped rangeland. Twelve percent is national forest and national wildlife refuge land. Less than 1 percent is covered by urban and rural communities. Colusa and Williams are the only incorporated cities in the county and they encompass about 2,574 acres (Colusa County 2011). Arbuckle is the largest unincorporated town of the unincorporated communities, which includes Arbuckle, College City, Century Ranch, Grimes, Maxwell, Princeton, and Stonyford. Together, these established incorporated and unincorporated towns cover a total area in "urban" uses of about 5,451 acres (Colusa County 2011). The majority of land within the CVP water service area in Colusa County is designated for agricultural use (Colusa County 2011; Reclamation 2005b).

The portion of the Central Valley Region, Sacramento Valley in Colusa County that could be affected by changes in CVP and/or SWP operations and evaluated in this EIS includes wildlife refuges (described in Chapter 10, Terrestrial Biological Resources) and CVP facilities, areas along the Sacramento River that use the surface waters (including agricultural lands), and CVP water service areas.

13.3.2.1.6 Butte County

Butte County encompasses 1,680 square miles in northern California. It is bounded on the north by Tehama County, on the east by Plumas County, on the west by Glenn and Colusa counties, and on the south by Sutter and Yuba counties. Butte County includes lands within national forests (Plumas and Lassen), Sacramento National Wildlife Refuge (Butte County 2010). State lands in Butte County include Big Chico Creek and Butte Creek ecological preserves; Table Mountain Reserve; Gray Lodge, Sacramento River, and Oroville wildlife areas; SWP facilities at Lake Oroville and Thermalito Reservoir; and more than 750 miles of rivers and streams.

The county comprises three general topographical areas: valley region, foothills east of the valley, and mountain region east of the foothills. Each of these regions contains distinct environments with unique wildlife and natural resources.

The U.S. Forest Service manages 135,427 acres (12 percent) within Butte County, including portions of the Plumas and Lassen National Forests. The Bureau of Land Management owns and manages 16,832 acres (1.5 percent) in the county

(Butte County 2010). Agriculture is the dominant land use within unincorporated Butte County, accounting for approximately 599,040 acres (60 percent of the county area) (Butte County 2010).

Butte County contains five incorporated municipalities: Biggs, Chico, Gridley, Oroville, and Paradise. Each has a general plan that guides development within its limits and larger planning area (Butte County 2010).

The portion of the Central Valley Region, Sacramento Valley, in Butte County that could be affected by changes in CVP and/or SWP operations and evaluated in this EIS includes wildlife refuges (described in Chapter 10, Terrestrial Biological Resources), SWP facilities (Lake Oroville and Thermalito Afterbay), CVP facilities, areas along the Feather River that use the surface waters (including agricultural lands), and CVP and SWP water service areas.

13.3.2.1.7 Sutter County

Sutter County encompasses approximately 607 square miles in northern California. It is bounded on the north by Butte County, on the east by Yuba and Placer counties, on the west by Colusa and Yolo counties, and on the south by Sacramento County. Sutter County includes lands within the Sutter National Wildlife Refuge. State lands in Sutter County include Butte Slough, Feather River, Gray Lodge, Sutter Bypass, and Butte Sink wildlife management areas; and Sutter Buttes State Park (Sutter County 2010).

Sutter County's General Plan was updated in 2011. Approximately 98 percent of the land in the County is unincorporated, and approximately 98 percent of the unincorporated land is zoned for agricultural use (Reclamation 2004). The two incorporated cities within the county, Yuba City and Live Oak, encompass approximately 10,600 acres.

Existing land use in Sutter County is rural and dominated by agricultural areas. The county has significant natural and recreational resources, and a relatively low population density. Existing land uses in Yuba City and Live Oak contain the bulk of the county's urban land uses, such as residences, commercial and industrial uses, parks, and public facilities (Sutter County 2010). The county includes several incorporated rural communities: Meridian, Sutter, Robbins, Rio Oso, Trowbridge, Nicolaus, East Nicolaus, and Pleasant Grove (Sutter County 2010).

The portion of the Central Valley Region, Sacramento Valley in Sutter County that could be affected by changes in CVP and/or SWP operations and evaluated in this EIS includes wildlife refuges (described in Chapter 10, Terrestrial Biological Resources), CVP facilities, areas along the Sacramento River that use the surface waters (including agricultural lands), and CVP and SWP water service areas.

13.3.2.1.8 Yuba County

Yuba County encompasses approximately 634 acres in northern California. It is bounded on the north by Butte County, on the east by Sierra and Nevada counties, on the west by Sutter County, and on the south by Placer County. Federally owned lands in Yuba County include Tahoe and Plumas National Forests, and the 22,944-acre Beale Air Force Base (Yuba County 2011). The Department of Fish and Wildlife administers the state Spenceville Wildlife Area.

Yuba County is predominantly rural. Over 189,500 acres (46 percent of the county), are designated for agricultural land uses. Most of the population lives in the two incorporated cities in the county (Marysville and Wheatland); and the major unincorporated communities including Brown's Valley, Brownsville, Camptonville, Dobbins, Linda/Olivehurst, Log Cabin, Loma Rica, Oregon House, Rackerby, and River Highlands (Yuba County 2011).

The portion of the Central Valley Region, Sacramento Valley in Yuba County that could be affected by changes evaluated in this EIS includes areas within Yuba County Water Agency facilities that provide water for environmental and water supply purposes within the Central Valley.

13.3.2.1.9 Nevada County

Nevada County encompasses approximately 634,880 acres in northern California. It is bounded on the north by Sierra County, on the northwest by Yuba County, on and on the south by Placer County. Federally owned lands in Nevada County include 169,686 acres in the Tahoe National Forest; 2,574 acres in the Toiyabe National Forest; and approximately 11,000 acres administered by the Bureau of Land Management (Nevada County 1995). The State Lands Commission manages approximately 4,600 acres; State Parks administers 6,300 acres at several locations, including Malakoff Diggins State Historical Park and Empire Mine State Park; and the Department of Fish and Wildlife administers approximately 11,000 acres at the Spenceville Wildlife Management and Recreation Area.

Nevada County is predominantly rural (Nevada County 2012). Approximately 91 percent of the county is used for agriculture, timber, or open space. Most of the population lives in the three incorporated cities in the county (Grass Valley, Nevada City, and Truckee).

13.3.2.1.10 Placer County

Placer County encompasses approximately 1,506 square miles in northern California. It is bounded on the north by Nevada County, on the east by the California-Nevada boundary, on the west by Yuba and Sutter counties, and on the south by Sacramento and El Dorado counties. Placer County includes lands within the El Dorado and Tahoe National Forests and other federally owned land (Placer County 2011).

Placer County is predominantly rural. Most of the population lives in the area along Interstate 80 from the City of Auburn to the Sutter and Sacramento county boundaries. Incorporated cities and towns include Roseville, Rocklin, Lincoln, Colfax, Loomis, and Auburn (Placer County 2011; Reclamation 2005c; SACOG 2007). Residential land uses range from rural residential areas to medium and high-density dwelling units in urbanized areas. Commercial land uses are primarily located in the urbanized portions of the county; although a large concentration of commercial development occurs outside existing urban areas along Interstate 80. Non-urban land uses include agriculture, resource extraction (timber and mining), and public lands and open space uses. The largest amount of public lands within Placer County is located in the eastern half of the county, and is under the jurisdiction of the Bureau of Land Management, U.S. Forest Service, or the Bureau of Reclamation. The CVP water service area within Placer County primarily includes the communities and agricultural areas in the western portion of the county. The portion of the Central Valley Region, Sacramento Valley in Placer County that could be affected by changes in CVP and/or SWP operations and evaluated in this EIS includes CVP water facilities (Folsom Lake), areas along the American River that use the surface waters (including agricultural lands), and CVP water service areas.

13.3.2.1.11 El Dorado County

El Dorado County encompasses approximately 1,790 square miles in northern California along the American River. It is bounded on the north by Placer County, on the east by California-Nevada boundaries, on the west by Sacramento County, and on the south by Amador and Alpine counties. El Dorado County includes about 521,210 acres (45.5 percent of the total county), under Federal ownership or trust, including lands within the El Dorado and Tahoe national forests. About 9,751 acres (8.5 percent of the county), is under the State jurisdiction (El Dorado County 2003).

The county includes two specific regions: the Lake Tahoe Basin and the western slopes of the Sierra Nevada (El Dorado County 2003). The CVP water service area provides water to a large portion of the communities and some agricultural areas along the western slope. El Dorado County includes two incorporated cities, Placerville and South Lake Tahoe, which cover 621 acres of land. Other major communities include El Dorado Hills, Cameron Park, Shingle Springs, Rescue, Diamond Springs, Camino, Coloma and Gold Hill, Cool and Pilot Hill, Georgetown and Garden Valley, Pollock Pines, Pleasant Valley, Latrobe, Somerset, and Mosquito. The rural land uses in the county include over 259,000 acres of private production forests, 153,472 acres of agricultural lands, and 35,282 acres within the waters of Folsom Lake and Lake Tahoe. The county’s two largest crops are wine grapes and apples.

The portion of the Central Valley Region, Sacramento Valley in El Dorado County that could be affected by changes in CVP and/or SWP operations and evaluated in this EIS includes CVP water facilities (Folsom Lake), areas along the American River that use the surface waters, and CVP water service areas.

13.3.2.1.12 Sacramento County

Sacramento County encompasses approximately 1,769 square miles in northern California. It is bounded on the north by Sutter and Placer counties, on the east by El Dorado and Amador counties, on the south by Contra Costa and San Joaquin counties, and on the west by Yolo and Solano counties. Sacramento County includes federally owned lands within Folsom Lake and Lake Natoma.

Residential areas in Sacramento County primarily occur in northern and central Sacramento County. Sacramento County includes areas within the Delta, including the southwestern portion of the City of Sacramento, City of Isleton and the communities of Locke, Ryde, Courtland, Freeport, Hood, and Walnut Grove; and areas located to the east of the Delta (Sacramento County 2011). Sacramento County has seven incorporated cities located in about 56 percent of the county: Sacramento, Elk Grove, Citrus Heights, Folsom, Galt, Isleton, and Rancho Cordova. The County includes several unincorporated communities including Antelope, Arden-Arcade, Carmichael, Cordova, Elverta, Foothill Farms, Fair Oaks, Herold, Natomas, North Highlands, Orangevale, Rancho Murieta, Rio Linda, Sloughhouse, and Wilton.

The leading agricultural crops in Sacramento County include dairy, wine grapes, Bartlett pears, field corn, and turkeys (Sacramento County 2010). Agricultural acreage has declined as urban development has continued. Between 1989 and 2004, the portion of the county designated as agriculture declined from 40 percent to 34 percent. The southeastern portion of the county remains primarily rural with smaller communities, such as Herald (Sacramento County 2011).

The portion of the Central Valley Region, Delta, in Sacramento County that could be affected by changes in CVP and/or SWP operations and evaluated in this EIS includes CVP facilities (Folsom Lake and Lake Natoma), areas along the American and Sacramento rivers and Delta channels that use the surface waters (including agricultural lands), and CVP water service areas.

13.3.2.1.13 Tribal Lands in Sacramento Valley

This section summarizes the tribal lands that could be affected by changes in CVP and/or SWP operations and that are located within the county boundaries.

Tribal Lands within the Boundaries of Shasta County

Major federally recognized tribes and tribal lands within the boundaries of Shasta County include the Pit River Tribe and the Redding Rancheria, which is a federal reservation of Wintun, Pit River, and Yana Indians near Redding (SDSU 2013).

Tribal Lands within the Boundaries of Tehama County

There are approximately 2,000 acres within the total acreage of Tehama County within tribal trust, including land near Corning owned by the Paskenta Band of Nomlaki Indians of California (Paskenta 2014).

Tribal Lands within the Boundaries of Glenn County

Major federally recognized tribes and tribal lands within the boundaries of Glenn County include the Grindstone Indian Reservation near Elk Creek at the Grindstone Indian Rancheria of Wintun-Wailaki Indians of California, and lands of the Paskenta Band of Nomlaki Indians of California.

Tribal Lands within the Boundaries of Colusa County

Major federally recognized tribes and tribal lands within the boundaries of Colusa County include the Cachil Dehe Band of Wintun Indians of the Colusa Indian

Community of the Colusa Rancheria, and the Cortina Indian Rancheria of Wintun Indians of California (Colusa County 2011).

Tribal Lands within the Boundaries of Butte County

Major federally recognized tribes and tribal lands within the boundaries of Butte County include the Tyme Maidu of Berry-Creek Rancheria on approximately 90 acres, and the Concow Maidu of Mooretown Rancheria on approximately 300 acres (Butte County 2010).

Tribal Lands within the Boundaries of Nevada County

Major federally recognized tribes and tribal lands within the boundaries of Nevada County include tribal trust lands of the Shingle Springs Band of Miwok Indians.

Tribal Lands within the Boundaries of Placer County

Major federally recognized tribes and tribal lands within the boundaries of Placer County include tribal trust lands of the United Auburn Indian Community of the Auburn Rancheria of California.

Tribal Lands within the Boundaries of El Dorado County

Major federally recognized tribes and tribal lands within the boundaries of El Dorado County include the Shingle Springs Band of Miwok Indians.

Tribal Lands within the Boundaries of Sacramento County

Major federally recognized tribes and tribal lands within the boundaries of Sacramento County include lands of the Wilton Miwok Indians of the Wilton Rancheria near Elk Grove (SACOG 2007).

13.3.2.2 San Joaquin Valley

The San Joaquin Valley includes Stanislaus, Merced, Madera, San Joaquin, Fresno, Kings, Tulare, and Kern counties. Other counties in this region are not anticipated to be affected by changes in CVP and SWP operations, and are not discussed here. They include Calaveras, Mariposa, and Tuolumne counties. Tribal lands are also described for the entire San Joaquin Valley.

13.3.2.2.1 Stanislaus County

Stanislaus County encompasses approximately 1,521 square miles in central California. It is bounded on the north by San Joaquin County, on the east by Calaveras and Tuolumne counties, on the west by Santa Clara County, and on the south by Merced County. Stanislaus County includes lands within the San Joaquin River National Wildlife Refuge (Stanislaus Council of Governments 2007).

Land use in the county is primarily agricultural, with nearly 80 percent of the land zoned for general agriculture or in agricultural production (Stanislaus Council of Governments 2007). Over the past 40 years, some portions of the county have been changing from a rural agricultural region to semi-urbanized, especially along major highways and freeways. There are nine incorporated cities in the county, including Ceres, Hughson, Modesto, Newman, Oakdale, Patterson, Riverbank, Turlock, and Waterford. Stanislaus County has adopted community plans for most of its unincorporated towns, including Crows Landing, Del Rio, Denair, Hickman, Keyes, Knights Ferry, La Grange, Westley, and Salida (Stanislaus County 2010, 2012).

The portion of the Central Valley Region, San Joaquin Valley, in Stanislaus County that could be affected by changes in CVP and/or SWP operations and evaluated in this EIS includes wildlife refuges (described in Chapter 10, Terrestrial Biological Resources), CVP water facilities (New Melones Reservoir, Delta-Mendota Canal, and San Luis Canal/California Aqueduct), areas along the Stanislaus and San Joaquin rivers that use the surface waters (including agricultural lands), and CVP water service areas.

13.3.2.2.2 Merced County

Merced County encompasses approximately 1,977 square miles in central California. It is bounded on the north by Stanislaus County, on the east by Mariposa County, on the south by Fresno and Madera counties, and on the west by Santa Clara and San Benito counties. Merced County includes federally owned lands within the San Luis National Wildlife Refuge (Merced County 2013). State lands within the county include San Luis Reservoir State Recreation Area; Great Valley Grasslands State Park; and the Los Banos, North Grasslands, and Volta wildlife areas.

Merced County includes the six incorporated cities of Atwater, Dos Palos, Gustine, Livingston, Los Banos, and Merced. The major unincorporated communities include Delhi, Fox Hills, Franklin, Hilmar, LeGrand, Planada, Santa Nella, Laguna San Luis, and Winton (Merced County 2013). Unincorporated land within the county includes approximately 1.2 million acres (98.1 percent of the land in the county). Agriculture is the primary land use, totaling just over 1 million acres (81.2 percent). Public and quasi-public land is the next largest use with 131,582 acres or 10.6 percent of the unincorporated County. Commercial land uses represent 3,025 acres (0.2 percent), industrial uses represent 2,488 acres (0.2 percent), and mining represents 3,375 acres (0.3 percent). Incorporated cities account for 24,138 acres (1.9 percent) (Merced County 2012a, 2013). The Merced County Local Agency Formation Commission policies discourage annexation of prime agricultural land when significant areas of non-prime agricultural land are already available. The policies also encourage development of vacant areas in cities before the annexation and development of outlying areas. Local Agency Formation Commission policies encourage city annexations that reflect a planned, logical, and orderly progression of urban expansion and promote efficient delivery of urban services (Merced County 2012b).

The portion of the Central Valley Region, San Joaquin Valley in Merced County that could be affected by changes in CVP and/or SWP operations and evaluated in this EIS includes wildlife refuges (described in Chapter 10, Terrestrial Biological Resources), CVP and SWP water facilities (San Luis Reservoir, Delta-Mendota Canal, and San Luis Canal/California Aqueduct), areas along the San Joaquin

River that use the surface waters (including agricultural lands), and CVP water service areas.

13.3.2.2.3 Madera County

Madera County encompasses approximately 2,147 square miles in central California. It is bounded on the north by Merced and Mariposa counties, on the east by Mono County, and on the south and west by Fresno County. Madera County includes lands within the Sierra and Inyo national forests (Madera County 1995). State lands within the county include the Millerton Lake State Recreation Area.

Land elevations in Madera County range from 180 feet to over 13,000 feet above mean sea level. Madera County can be divided generally into three regions – the San Joaquin Valley in the west, the foothills between the Madera Canal and the 3,500-foot elevation contour, and the mountains from the 3,500-foot contour to the crest of the Sierra Nevada. The County has two incorporated cities, Madera and Chowchilla (Madera County 1995). Major unincorporated communities in the county include North Fork, South Fork, O’Neals, Oakhurst, Coarsegold, Gunner Ranch, and Rio Mesa.

The portion of the Central Valley Region, San Joaquin Valley, in Madera County that could be affected by changes in CVP and/or SWP operations and evaluated in this EIS includes CVP water facilities (Millerton Lake and the Madera Canal), areas along the San Joaquin River that use the surface waters (including agricultural lands), and CVP water service areas.

13.3.2.2.4 San Joaquin County

San Joaquin County encompasses approximately 1,426 square miles in central California. It is bounded on the north by Sacramento County, on the east by Calaveras and Amador counties, on the south by Stanislaus County, and on the west by Contra Costa and Alameda counties. San Joaquin County includes about 6,000 acres of federally owned lands (San Joaquin County 2009).

San Joaquin County is currently in the process of updating its General Plan. Most of the county’s land is in agricultural production. Agriculture, the predominant land use, covers 686,109 acres (75 percent) of the county. Residential land is the second largest use in the unincorporated lands, encompassing 40,410 acres (4.4 percent of the county). Residential development in the county is concentrated in existing cities and in adjacent unincorporated communities. San Joaquin County has seven incorporated cities: Stockton, Tracy, Manteca, Escalon, Ripon, Lodi, and Lathrop. Stockton and Tracy are the largest cities in the county. The major unincorporated areas in the county include French Camp, Linden, Lockeford, Morada, Mountain House, New Jerusalem, Thornton, and Woodbridge (San Joaquin County 2009). The incorporated cities account for 90,191 acres (approximately 10 percent of the county).

The portion of the Central Valley Region, Delta in San Joaquin County that could be affected by changes in CVP and/or SWP operations and evaluated in this EIS includes CVP and SWP facilities (including facilities associated with Rock

Slough Pumping Plant, Jones Pumping Plant, Clifton Court, and Banks Pumping Plant), areas along the Delta channels that use the surface waters (including agricultural lands), and CVP water service areas.

13.3.2.2.5 Fresno County

Fresno County encompasses approximately 6,000 square miles in central California. It is bounded on the north by Merced and Madera counties, on the east by Mono and Inyo counties, on the south by Kings and Tulare counties, and on the west by San Benito and Monterey counties. Fresno County includes lands within Millerton Lake, Pine Flat Lake, the Sierra and Sequoia national forests, Sequoia National Monument, and Kings Canyon National Park (Fresno County 2000). State lands within the county include the Millerton Lake State Recreation Area, San Joaquin River Parkway, and Mendota Wildlife Area.

Fresno County is California's sixth-largest county. Agricultural land uses cover over 48 percent of the county, and resource conservation lands (e.g., forests, parks, and timber preserves) cover approximately 45 percent of the county. The 15 incorporated cities and unincorporated communities cover approximately 5 percent of the county (Fresno County 2000). Development constraints within the county are primarily caused by lack of funding for infrastructure improvement, availability of water supplies, air quality regulations, and physical limitations, especially in the mountains and eastern foothills. The incorporated communities include Clovis, Coalinga, Firebaugh, Fowler, Fresno, Huron, Kerman, Kingsburg, Mendota, Orange Cove, Parlier-West Parlier, Reedley, Sanger, San Joaquin, and Selma (Fresno County 2000). Major unincorporated communities include Biola, Caruthers, Del Rey, Friant, Lanare, Laton, Riverdale, Shaver Lake, and Tranquility.

The portion of the Central Valley Region, San Joaquin Valley in Fresno County that could be affected by changes in CVP and/or SWP operations and evaluated in this EIS includes CVP water facilities (Millerton Lake and the Friant-Kern Canal), areas along the San Joaquin River that use the surface waters, and CVP water service areas (including agricultural lands), and CVP water service areas.

13.3.2.2.6 Kings County

Kings County encompasses approximately 1,280 square miles in south central California. It is bounded on the north by Fresno County, on the east by Tulare County, on the south by Kern County, and on the west by Monterey County. Kings County includes lands within Naval Air Station Lemoore (Kings County 2009).

Land use is predominantly agricultural, with more than 90 percent of the county designated for agricultural uses. Incorporated cities in Kings County include Avenal, Corcoran, Hanford, and Lemoore. Residential land uses in unincorporated areas and special districts cover less than 1 percent of the county’s total acreage including for the communities of Armona, Home Garden, Kettleman City, and Stratford (Kings County 2009).

The portion of the Central Valley Region, San Joaquin Valley, in Kings County that could be affected by changes in CVP and/or SWP operations and evaluated in this EIS includes CVP and SWP water service areas.

13.3.2.2.7 Tulare County

Tulare County encompasses approximately 4,840 square miles in south central California. It is bounded on the north by Fresno County, on the east by Inyo County, on the south by Kern County, and on the west by Kings County. Tulare County includes federally owned lands within the Sequoia National Forest, Sequoia and Kings Canyon National Parks, Sequoia National Monument, several wilderness areas, Lake Kaweah, Lake Success, and Pixley National Wildlife Refuge (Tulare County 2010).

Agricultural land uses cover more than 2,150 square miles (approximately 44 percent) of the county. Lands classified as open space (i.e., national forests, monuments, and parks; wilderness areas; and County parks) make up 25 percent of the land use in the county. Less than 3 percent of the county lands are in the incorporated cities of Dinuba, Exeter, Farmersville, Lindsay, Porterville, Tulare, Visalia, and Woodlake (Tulare County 2010). Less than 2 percent of the county is designated for unincorporated residential areas, including the major communities of Alpaugh, Cutler, Ducor, Earlimart, East Oros, Goshen, Ivanhoe, Lemoncove, London, Oros, Pixley, Plainview, Poplar-Cotton Center, Richgrove, Springville, Strathmore, Terra Bella, Three Rivers, Tipton, Traver, and Woodville.

The portion of the Central Valley Region, San Joaquin Valley, in Tulare County that could be affected by changes in CVP and/or SWP operations and evaluated in this EIS includes CVP water service areas.

13.3.2.2.8 Kern County

Kern County encompasses approximately 8,202 square miles in south central California. It is bounded on the north by Kings, Tulare, and Inyo counties; on the east by San Bernardino County, on the south by Ventura and Los Angeles counties; and on the west by San Luis Obispo County. Kern County includes lands within the Sequoia National Forest, Kern and Bitter Creek national wildlife refuges, Lake Isabella, China Lake Naval Air Weapons Station, and Edwards Air Force Base (Kern County 2004). State lands within the county include the Tule Elk State Reserve.

The county's geography includes mountainous regions, agricultural lands, and deserts. There are 11 incorporated cities in the county, including Arvin, Bakersfield, California City, Delano, Maricopa, McFarland, Ridgecrest, Shafter, Taft, Tehachapi, and Wasco (Kern County 2009). The major unincorporated communities include Kernville, Lake Isabella, Inyokern, Mojave, Boron, Rosamond, Golden Hills, Stallion Springs, and Buttonwillow. Agricultural land uses are designated for approximately 85 percent of the unincorporated lands that are under the jurisdiction of the county (not including lands under the jurisdiction of the Federal, state, tribes, or incorporated cities). Less than 6 percent of the unincorporated lands under county jurisdiction are designated for residential uses.

The portion of the Central Valley Region, San Joaquin Valley, in Kern County that could be affected by changes in CVP and/or SWP operations and evaluated in this EIS includes CVP and SWP water service areas.

13.3.2.2.9 Tribal Lands in San Joaquin Valley

This section summarizes the tribal lands that could be affected by changes in CVP and/or SWP operations and that are located within the county boundaries described above.

Tribal Lands within the Boundaries of Madera County

Major federally recognized tribes and tribal lands within the boundaries of Madera County include the Picayune Rancheria of the Chuckchansi Indians of California near the community of Coarsegold and the Northfork Rancheria of the Mono Indians of California near Northfork (SDSU 2013).

Tribal Lands within the Boundaries of Fresno County

Major federally recognized tribes and tribal lands within the boundaries of Fresno County include the lands of the Big Sandy Rancheria of the Western Mono Indians of California and Table Mountain Rancheria of California.

Tribal Lands within the Boundaries of Kings County

Major federally recognized tribes and tribal lands within the boundaries of Kings County includes the lands of the Santa Rosa Indian Community of Santa Rosa Rancheria near the town of Lemoore (SDSU 2013).

Tribal Lands within the Boundaries of Tulare County

Major federally recognized tribes and tribal lands within the boundaries of Tulare County includes the Tule River Indian Tribe of the Tule River Reservation of the Yokut Indians about 20 miles east of Porterville and covers 55,356 acres (SDSU 2013).

13.3.2.3 Delta and Suisun Marsh

The Delta and Suisun Marsh includes Sacramento, Yolo, Solano, San Joaquin, and Contra Costa counties. Sacramento County is discussed in the Sacramento Valley subsection because more of the land that could be affected by changes in CVP and SWP long-term operations is located within the Sacramento Valley than in the Delta and Suisun Marsh geographical areas. San Joaquin County is discussed in the San Joaquin Valley subsection because more of the land that could be affected by changes in CVP and SWP long-term operations is located within the San Joaquin Valley than in the Delta and Suisun Marsh geographical areas. Contra Costa County is discussed as part of the San Francisco Bay Region because more of the land that could be affected by changes in CVP and SWP long-term operations is located within the San Francisco Bay Region than in the Delta and Suisun Marsh geographical areas.

13.3.2.3.1 Yolo County

Yolo County encompasses approximately 1,021 square miles in northern California. It is bounded on the north by Colusa County, on the east by Sutter and Sacramento counties, on the south by Solano County, and on the west by Lake and Napa counties. Yolo County includes federally owned lands in the Yolo Bypass and Cache Creek areas and state lands within the Yolo Bypass.

Residential areas in Yolo County primarily occur in the county's four incorporated cities (Davis, West Sacramento, Winters, and Woodland) that comprise approximately 32,325 acres (5 percent) of county lands (Yolo County 2009). Yolo County includes areas within the Delta, including the City of West Sacramento and the community of Clarksburg. The unincorporated portion of the county encompasses 35 community areas, including Capay, Clarksburg, Dunnigan, Esparto, Guinda, Knights Landing, Madison, Monument Hills, Rumsey, Yolo, and Zamora.

Yolo County adopted its 2030 General Plan in 2011. The general plan designates more than 92 percent of the County area for agricultural and open space uses. The major crops are tomatoes, alfalfa, wine grapes, rice, seed crops, almonds, organic production, walnuts, cattle, and wheat (Yolo County 2009).

The 59,000-acre Yolo Bypass is primarily located within Yolo County and includes a portion of the Sacramento River Flood Control Project, as described in Chapter 5, Surface Water Resources and Water Supplies (CALFED et al. 2001). The upper section of the Yolo Bypass is defined as the area between Fremont Weir and Interstate 80 and is located within Yolo County. The lower section is defined as the area between Interstate 80 and the southern boundary of Egbert Tract at the Sacramento River. The portion of the southern area located to the north of the upper Holland Tract and upper Liberty Island is within Yolo County. In the northern area, agricultural crops include rice, corn, and safflower with melons and tomatoes planted in years when the bypass is not inundated with flood waters. The southern bypass crops include corn, milo, safflower, beans, and sudan grass. Approximately 16,770 acres in the southern Yolo Bypass is within the Yolo Bypass Wildlife Area (Yolo County 2009).

The portion of the Central Valley Region, Delta in Yolo County that could be affected by changes in CVP and/or SWP operations and evaluated in this EIS includes areas in the Yolo Bypass and along the Delta channels that use the surface waters (including agricultural lands), and CVP water service areas.

13.3.2.3.2 Solano County

Solano County encompasses approximately 910 square miles in northern California. It is bounded on the north by Yolo County, on the east by Sutter and Sacramento counties, on the south by Contra Costa County, and on the west by Napa County. Solano County includes federally owned lands within Travis Air Force Base (Solano County 2008). State lands include areas within Suisun Marsh and the Cache Slough area of Yolo Bypass.

Solano County's General Plan was adopted in 2008. Approximately 81,678 acres of the county (14 percent of the total land area), lies within seven incorporated cities: Benicia, Dixon, Fairfield, Rio Vista, Suisun City, Vacaville, and Vallejo. Urban development is generally concentrated within the incorporated cities or surrounding suburban communities. Travis Air Force Base is located on approximately 7,100 acres (1 percent of the land within the county). In 2006, agriculture accounted for 56.5 percent of the total land use in Solano County (Solano County 2008). The southern section of the Yolo Bypass, as described under the Yolo County subsection, is located within Solano County.

The portion of the Central Valley Region, Delta in Solano County that could be affected by changes in CVP and/or SWP operations and evaluated in this EIS includes SWP facilities (North Bay Aqueduct intakes at Barker Slough), areas in the Yolo Bypass and along the Delta channels that use the surface waters (including agricultural lands), and CVP and SWP water service areas.

13.3.2.3.3 Tribal Lands in Delta and Suisun Marsh

This section summarizes the tribal lands that could be affected by changes in CVP and/or SWP operations and that are located within the county boundaries described above.

Tribal Lands within the Boundaries of Yolo County

Major federally recognized tribes and tribal lands within the boundaries of Yolo County include lands of the Yocha Dehe Wintun Nation (previously called the Rumsey Indian Rancheria of Wintun Indians of California) (Yolo County 2009).

13.3.3 San Francisco Bay Area Region

The San Francisco Bay Area Region includes portions of Napa, Contra Costa, Alameda, Santa Clara, and San Benito counties that are within the CVP and SWP service areas.

13.3.3.1.1 Napa County

Napa County encompasses approximately 793 square miles in northern California. It is bounded on the north by Lake County, on the east by Yolo County, on the south by Solano County, and on the west by Sonoma County. Napa County includes 62,865 acres of federally owned and 40,307 acres of state-owned lands throughout the county, including approximately 28,000 acres related to Lake Berryessa and the State Cedar Rough Wilderness and Wildlife Area (Napa County 2007).

Approximately 479,000 acres (95 percent) of the county, are unincorporated. The five incorporated cities include American Canyon, Calistoga, Napa, and St. Helena, and the town of Yountville. Land use in the county is predominantly agricultural (Napa County 2007, 2008).

The portion of the San Francisco Bay Area Region in Napa County that could be affected by changes in CVP and/or SWP operations and evaluated in this EIS includes SWP water service areas.

13.3.3.1.2 Contra Costa County

Contra Costa County encompasses approximately 805 square miles in northern California. It is bounded on the north by Solano and Sacramento counties, on the east by San Joaquin County, on the south by Alameda County, and on the west by San Francisco Bay. Contra Costa County includes federally owned and state-owned lands throughout the county, including approximately 20,000 acres within Mount Diablo State Park (Contra Costa County 2005).

Over 40 percent of the county's land is in agricultural production, or about 200,370 acres. Residential land is the second largest use in the county, encompassing approximately 122,100 acres (25.4 percent of the county). Approximately 46,700 acres (9 percent of the land within the county), are within surface waters (Contra Costa County 2005).

Residential development is concentrated in existing cities and adjacent unincorporated communities. The Contra Costa County incorporated cities include Antioch, Brentwood, Clayton, Danville, El Cerrito, Hercules, Lafayette, Martinez, Moraga, Oakley, Orinda, Pinole, Pleasant Hill, Pittsburg, Richmond, San Pablo, San Ramon, and Walnut Creek. The major unincorporated areas in the county include Alamo, Bethel Island, Byron, Crockett, Discovery Bay, Kensington, Knightsen, North Richmond, Pacheco, Port Costa, and Rodeo (Contra Costa County 2005). Portions of the cities of Pittsburg, Antioch, Oakley, and Brentwood and eastern Contra Costa County are located within the Delta.

The portion of the San Francisco Bay Area Region in Contra Costa County that could be affected by changes in CVP and/or SWP operations and evaluated in this EIS includes CVP facilities (including facilities associated with Rock Slough), areas along the Delta channels that use the surface waters (including agricultural lands), and CVP water service areas.

13.3.3.1.3 Alameda County

Alameda County encompasses approximately 738 square miles in northern California. It is bounded on the north by Contra Costa County, on the east by San Joaquin County, on the south by Santa Clara County, and on the west by San Francisco Bay. Alameda County includes federally owned and state-owned lands throughout the county (Alameda County 2009).

Western Alameda County and the portions of the Livermore-Amador Valley are heavily urbanized. The incorporated cities include Oakland, which is the County seat; Alameda, Albany, Berkeley, Dublin, Emeryville, Fremont, Hayward, Livermore, Newark, Piedmont, Pleasant, San Leandro, and Union City. The unincorporated area of the County covers approximately 277,760 acres (59 percent) of the total land area, includes the unincorporated areas of Castro Valley, Eden Area, and (Alameda County Community Development Agency 2010; Alameda County 2000, 2009). Large portions of the unincorporated areas located to the east of Castro Valley and within the Livermore-Amador Valley hills include agricultural and open space lands which are not served by the CVP or SWP water supplies.

The portion of the San Francisco Bay Area Region in Alameda County that could be affected by changes in CVP and/or SWP operations and evaluated in this EIS includes CVP and SWP facilities (including the SWP South Bay Aqueduct), reservoirs that store CVP or SWP water, and CVP and SWP water service areas.

13.3.3.1.4 Santa Clara County

Santa Clara County encompasses approximately 1,306 square miles in northern California. It is bounded on the north by Alameda County, on the east by Stanislaus and Merced counties, on the south by San Benito County, and on the west by San Mateo and Santa Cruz counties. Santa Clara County includes federally owned and state-owned lands throughout the county, including approximately 87,000 acres within Henry W. Coe State Park (Santa Clara County 1994, 2012).

Approximately 83 percent of the county's population resides in the 15 incorporated cities. The incorporated cities include Campbell, Cupertino, Gilroy, Los Altos, Los Altos Hills, Los Gatos, Milpitas, Monte Sereno, Morgan Hill, Mountain View, Palo Alto, San Jose, Santa Clara, Saratoga, and Sunnyvale. The southern portion of the county near Gilroy and Morgan Hill is predominantly rural, with low-density residential developments scattered though the valley and foothill areas (Santa Clara County 1994, 2012).

The portion of the San Francisco Bay Area Region in Santa Clara County that could be affected by changes in CVP and/or SWP operations and evaluated in this EIS includes CVP and SWP facilities (including the SWP South Bay Aqueduct and CVP facilities that convey water from San Luis Reservoir) and CVP and SWP water service areas.

13.3.3.1.5 San Benito County

San Benito County encompasses approximately 1,386 square miles in central California. It is bounded on the north by Santa Clara County, on the east by Merced and Fresno counties, and on the south and west by Monterey County. San Benito County includes federally owned and state-owned lands throughout the county, including approximately 26,000 acres within Pinnacles National Monument, over 105,403 acres owned by Bureau of Land Management, and over 8,800 acres associated with the Hollister Hills State Vehicular Recreation Area and San Juan Bautista State Historic Park (San Benito County 2010, 2013).

San Benito County has approximately 882,675 acres of unincorporated lands (nearly 99.5 percent of the total land area). The incorporated cities of Hollister and San Juan Bautista account for approximately 4,044 acres (0.5 percent of the county land area). Agriculture is the predominant land use, totaling 747,409 acres (84 percent of the county) (San Benito County 2010, 2013).

The portion of the San Francisco Bay Area Region in San Benito County that could be affected by changes in CVP and/or SWP operations and evaluated in this EIS includes CVP and SWP facilities (including San Justo Reservoir and other facilities to convey water from San Luis Reservoir) and CVP water service areas.

13.3.4 Central Coast Region

The Central Coast Region includes portions of San Luis Obispo and Santa Barbara counties served by the SWP. Tribal lands are also described for the Central Coast Region.

13.3.4.1 San Luis Obispo County

San Luis Obispo County encompasses approximately 3,594 square miles in central California, including over 200,000 acres of surface waters (San Luis Obispo County 2013). It is bounded on the north by Monterey County, on the east by Kern County, on the south by Santa Barbara County, and on the west by the Pacific Ocean. Federally owned land in San Luis Obispo County includes Los Padres National Forest, Carizzo Plain National Monument, several wilderness areas, and Guadalupe-Nipomo Dunes National Wildlife Refuge. State-owned lands include Hearst-San Simeon State Historical Monument, Montano de Oro State Park, and state beaches and marine conservation areas.

Land uses in the County are predominantly rural and agricultural with over 1,672,000 acres in agricultural and rural land uses (83 percent of the total county lands). Incorporated cities include Arroyo Grande, Atascadero, Grover Beach, Morro Bay, Paso Robles, Pismo Beach, and San Luis Obispo. Major unincorporated communities include Avila, California Valley, Creston Village, Edna Village, Heritage Ranch, Los Ranchos, Nipoma, Oak Shores, Oceano, San Miguel, Santa Margarita, and Templeton (San Luis Obispo County 2013).

The portion of the Central Coastal Region in San Luis Obispo County that could be affected by changes in CVP and/or SWP operations and evaluated in this EIS includes SWP facilities (including facilities associated with the Central Coast Water Authority) and SWP water service areas.

13.3.4.2 Santa Barbara County

Santa Barbara County encompasses approximately 2,744 square miles in central California. It is bounded on the north by San Luis Obispo, on the east by Ventura County, and on the south and west by the Pacific Ocean. Federally owned land in Santa Barbara County includes 629,120 acres in the Los Padres National Forest, 98,560 acres in the Vandenberg Air Force Base, Channel Islands National Park, and Guadalupe-Nipomo Dunes National Wildlife Refuge. The state-owned lands include the University of California at Santa Barbara, Sedgwick Reserve, La Purisima Mission State Park and other state parks, and Burton Mesa Ecological Reserve (Santa Barbara County 2009; SBCAG 2013).

Agricultural is the predominant land use in the county with over 1,440,000 acres (82 percent of the land) (Santa Barbara County 2009; SBCAG 2013). Santa Barbara County includes eight incorporated cities, Buellton, Carpinteria, Goleta, Guadalupe, Lompoc, Santa Barbara, Santa Maria, and Solvang. Less than 3 percent of the County is within incorporated cities. The major unincorporated communities include Cuyuama, Los Alamos, Los Olivos, Mission Hills, Montecito, New Cayamu, Orcutt, Summerland, and Vandendberg Village. The portion of the Central Coastal Region, in Santa Barbara County, that could be affected by changes in CVP and/or SWP operations and evaluated in this EIS includes SWP facilities (including facilities associated with the Central Coast Water Authority), recreation facilities at Cachuma Lake that stores SWP water, and SWP water service areas.

13.3.4.3 Tribal Lands in Central Coast Region

This section summarizes the tribal lands that could be affected by changes in CVP and/or SWP operations and that are located within the county boundaries described above.

Tribal Lands within the Boundaries of Santa Barbara County

Major federally recognized tribes and tribal lands within the boundaries of Santa Barbara County include the Santa Ynez Reservation, which is home to the Santa Ynez Band of Chumash Mission Indians of the Santa Ynez Reservation near Santa Barbara (SDSU 2013).

13.3.5 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. Tribal lands are also described for the Southern California Region.

13.3.5.1 Ventura County

Ventura County encompasses approximately 1,873 square miles in southern California. It is bounded on the north by Kern County, on the east and south by Los Angeles County, and on the west by Santa Barbara County and the Pacific Ocean. Ventura County includes federally owned and state-owned lands throughout the county, including 550,211 acres in Los Padres National Forest, Chumash and Sespe wilderness area, 4,331 acres at the Point Mugu Naval Air Station, 670 acres at the California State University Channel Islands, and over 410 acres in state beach parks (Ventura County 2013).

Ventura County has 10 incorporated cities, including Camarillo, Fillmore, Moorpark, Ojai, Oxnard, Port Hueneme, Santa Paula, San Buenaventura, Simi Valley, and Thousand Oaks (Ventura County 2013). Major unincorporated communities within the county include Bell Canyon, Box Canyon, Camarillo Heights, Del Norte, El Rio, Hidden Valley, Lake Sherwood, Matilija Canyon, Montalvo, Oak Park, Ojai Valley, Piru, Saticoy, and Somis (Ventura County 2005).

The portion of the Southern California Region in Ventura County that could be affected by changes in CVP and/or SWP operations and evaluated in this EIS includes recreation at Lake Piru that stores SWP water, and SWP water service areas.

13.3.5.2 Los Angeles County

Los Angeles County encompasses approximately 4,083 square miles in northern California. It is bounded on the north by Kern County, on the east by San Bernardino County, on the south by Orange County, and on the west by Ventura

County and the Pacific Ocean. Los Angeles County includes federally owned and state-owned lands throughout the county, including nearly 650,000 acres in Los Padres and Angeles national forests, portions of Edwards Air Force Base, over 29,000 acres of other federally owned open space (including wilderness areas), and approximately 50,893 acres of state-owned land, including Hungry Valley State Vehicular Recreation Area (Los Angeles County 2011).

More than half of Los Angeles County's 1,698,240 acres of unincorporated land area is designated a natural resources land use category. The next highest land use is rural, which accounts for 39 percent of the unincorporated areas, followed by residential, which accounts for 3 percent of the unincorporated areas. The remaining land area is in the county's 88 incorporated cities, the most populous of which is the City of Los Angeles (Los Angeles County 2012). The County has approximately 140 unincorporated areas (Los Angeles County 2014).

The portion of the Southern California Region in Los Angeles County that could be affected by changes in CVP and/or SWP operations and evaluated in this EIS includes SWP facilities and SWP water service areas.

13.3.5.3 Orange County

Orange County encompasses 948 square miles in southern California. It is bounded on the north by Los Angeles County, on the east by San Bernardino and Riverside counties, on the south by San Diego County, and on the west by the Pacific Ocean. Orange County includes federally owned lands, including lands in the Cleveland National Forests.

Orange County has 34 incorporated cities in Orange County. The unincorporated lands cover approximately 192,758 acres (Orange County 2005). Land zoned as open space forms the largest land use type (143,313 acres).

The portion of the Southern California Region in Orange County that could be affected by changes in CVP and/or SWP operations and evaluated in this EIS includes SWP facilities and SWP water service areas.

13.3.5.4 San Diego County

San Diego County encompasses approximately 4,525 square miles in southern California. It is bounded on the north by Orange and Riverside counties, on the east by Imperial County, on the south by Mexico, and on the west by the Pacific Ocean. San Diego County includes federally owned land, including Camp Pendleton Marine Corps Base, Cleveland National Forest, and San Diego and San Diego national wildlife refuges. State-owned lands throughout the county, includes Cuyamaca Rancho State Park, Anza-Borrego Desert State Park, Felipe Wildlife Area, and Ocotillo Wells State Vehicular Recreation Area (San Diego County 2011).

The incorporated cities include Carlsbad, Chula Vista, Coronado, Del Mar, El Cajon, Encinitas, Escondido, Imperial Beach, La Mesa, Lemon Grove, National City, Oceanside, Poway, San Marcos, Santee, Solano Beach, and Vista San Diego (San Diego County 2011). The unincorporated communities include Lakeside, Ramona, San Dieguito, Spring Valley, and Valle de Oro.

The portion of the Southern California Region in San Diego County that could be affected by changes in CVP and/or SWP operations and evaluated in this EIS includes SWP facilities, non-SWP reservoirs that store SWP water (including Dixon Lake; and San Vicente, Lower Otay, and Sweetwater Reservoir), and CVP water service areas.

13.3.5.5 Riverside County

Riverside County encompasses approximately 7,295 square miles in southern California. It is bounded on the north by San Bernardino County, on the east by the state of Nevada, on the south by San Diego and Imperial counties, and on the west by Orange County. Riverside County includes federally owned lands throughout the county, including March Air Reserve Base, Chocolate Mountains Naval Gunnery Range, Joshua Tree National Park, San Bernardino and Cleveland national forests, numerous wilderness areas, and Coachella Valley National Wildlife Refuge; and state-owned lands including San Jacinto and Santa Rose wildlife areas and Mount San Jacinto State Park (RCIP 2000).

Residential land use accounts for approximately 184,000 acres, nearly 57 percent of which are within incorporated cities. Approximately 1,313,000 acres (28 percent) is in open space, recreation, agriculture, and wildland preservation (RCIP 2000).

Most of the population is concentrated in the 24 incorporated cities of Banning, Beaumont, Calimesa, Canyon Lake, Cathedral City, Coachella, Corona, Desert Hot Springs, Hemet, Indian Wells, Indio, Lake Elsinore, La Quinta, Moreno Valley, Murrieta, Norco, Palm Desert, Palm Springs, Perris, Rancho Mirage, Riverside, San Jacinto, and Temecula. The major unincorporated communities in the county include Banning Bench, Bermuda Dunes, Cabazon, Cherry Valley, Cleveland Ridge, Desert Center, Eagle Mountain, El Cerrito, Lakeview/Nuevo, Meadowbrook, Mecca, Menifee Valley, North Palm Springs, Ripley, Sun City, Temescal Canyon, Tenaja, Thermal, Thousand Palms, Warm Springs, and Wildomar.

The portion of the Southern California Region in Riverside County that could be affected by changes in CVP and/or SWP operations and evaluated in this EIS includes SWP facilities, reservoirs that store SWP water (including Diamond Valley Lake and Lake Skinner), and SWP water service areas.

13.3.5.6 San Bernardino County

San Bernardino County encompasses approximately 20,106 square miles in southern California. It is bounded on the north by Inyo County, on the east by the state of Nevada, on the south by Riverside County, and on the west by Kern, Los Angeles, and Orange counties. Most of the land in San Bernardino County is federally owned and state-owned lands, including approximately 10,500,000 acres (81 percent of the county) (San Bernardino County 2007, 2012). The federally owned lands include 28 Bureau of Land Management wilderness areas (approximately 47 percent of the total county), San Bernardino and Angeles National Forests (676,666 and 655,387 acres, respectively), Mojave National

Preserve, Joshua Tree and Death Valley National Parks, and four military bases (Edwards Air Force Base, Twentynine Palms Marine Corps Air Ground Combat Training Center, Fort Irwin, and China Lake Naval Weapons Center). State-owned lands include Silverwood Lake State Recreation Area at the SWP reservoir, Wildwood Canyon State Park, and Providence Mountain and Chino Hills state recreation areas.

San Bernardino County includes 24 incorporated cities, including Adelanto, Apple Valley, Barstow, Big Bear Lake, Chino, Chino Hills, Colton, Fontana, Grand Terrace, Hesperia, Highland, Loma Linda, Montclair, Needles, Ontario, Rancho Cucamonga, Redlands, Rialto, San Bernardino, Twentynine Palms, Upland, Victorville, Yucaipa, and Yucca Valley. Major unincorporated communities in the county include Amboy, Baker, Bear Valley, Bloomington, Crest Forest, Earp, Essex, Fontana suburbs, Goffs, Harvard, Havasu Lake, Helendale, Hilltop, Hinckley, Homestead Valley, Joshua Tree, Kelso, Kramer Junction, Lake Arrowhead, Landers, Lucerne Valley, Ludlow, Lytle Creek, Mentone, Moronga Valley, Muscoy, Newberry Springs, Nipton, Oak Glen, Oak Hills, Parker, Phelan/Pinon Hills, Pioneertown, Red Mountain, Rimrock, Silver Lake, Trona, Vidal, and Yerno.

The portion of the Southern California Region in San Bernardino County that could be affected by changes in CVP and/or SWP operations and evaluated in this EIS includes SWP water service areas.

13.3.5.7 Tribal Lands in Southern California Region

This section summarizes the tribal lands that could be affected by changes in CVP and/or SWP operations and that are located within the county boundaries described above.

Tribal Lands within the Boundaries of San Diego County

Major federally recognized tribes and tribal lands within the boundaries of San Diego County includes lands of the Capitan Grande Band of Diegueno Mission Indians of California (Barona Reservation and Viejas Reservation), Cahuilla Band of Mission Indians of the Cahuilla Reservation, Campo Band of Diegueno Mission Indians of the Campo Indian Reservation, Ewiiaapaayp Band of Kumeyaay Indians, Inaja Band of Diegueno Mission Indians of the Inaja and Cosmit Reservation, Jamul Indian Village of California, La Jolla Band of Luiseno Indians, La Posta Band of Diegueno Mission Indians of the La Posta Indian Reservation, Los Coyotes Band of Cahuilla and Cupeno Indians, Manzanita Band of Diegueno Mission Indians of the Manzanita Reservation, Mesa Grade Band of Diegueno Mission Indians of the Mesa Grande Reservation, Pala Band of Luiseno Mission Indians of the Pala Reservation, Pauma Band of Luiseno Mission Indians of the Pauma & Yuima Reservation, Rincon Band of Luiseno Indians of the Rincon Reservation, San Pasqual Band of Diegueno Mission Indians of California, Iipay Nation of Santa Ysabel, and Sycuan Band of Kumeyaay Nation.

Tribal Lands within the Boundaries of Riverside County

Major federally recognized tribes and tribal lands within the boundaries of Riverside County include lands of the Agua Caliente Band of Cahuilla Indians of the Agua Caliente Reservation, Augustine Band of Cahuilla Indians, Cabazon Band of Mission Indians, Cahuilla Band of Mission Indians of the Cahuilla Reservation, Morango Band of Mission Indians, Pechanga Band of Luiseno Mission Indians of the Pechanga Reservation, Ramona Band of Cahuilla, Santa Rosa Band of Cahuilla Indians, Soboba Band of Luiseno Indians, Torres-Martinez Desert Cahuilla Indians, Twenty-Nine Palms Band of Mission Indians of California, and Colorado River Indian Tribes of the Colorado River Indian Reservation (RCIP 2000).

Tribal Lands within the Boundaries of San Bernardino County

Major federally recognized tribes and tribal lands within the boundaries of San Bernardino County include the lands of the San Manual Band of Mission Indians and the Twenty-Nine Palms Band of Mission Indians of California (SDSU 2013). The Chemehuevi Indian Tribe of the Chemehuevi Reservation is also located in San Bernardino County near the Colorado River.

13.4 Impact Analysis

This section describes the potential mechanisms for change in non-agricultural land uses and analytical methods; results of the impact analysis; potential mitigation measures; and potential cumulative effects.

13.4.1 Potential Mechanisms for Change and Analytical Tools

As described in Chapter 4, Approach to Environmental Analysis, the environmental consequences assessment considers changes in non-agricultural land uses related to changes in CVP and SWP operations under the alternatives as compared to the No Action Alternative and Second Basis of Comparison.

13.4.1.1 Changes in Land Uses

Land uses in 2030 are assumed to be consistent with the future projections included in existing general plans. The general plans were developed assuming adequate water supplies to support the projected lands uses. Changes in CVP and SWP operations under the No Action Alternative and Alternatives 1 through 5 could change the availability of CVP and SWP water supplies. If the CVP and SWP water supplies were reduced as compared to the No Action Alternative and Second Basis of Comparison to a level that would not support planned municipal and industrial water demands, development of future land uses may not occur. Potential changes to agricultural land uses are described in Chapter 12, Agricultural Resources.

Availability of CVP and SWP water supplies were analyzed using CalSim II model output (see Chapter 5, Surface Water Resources and Water Supplies). Most of the CVP and SWP municipal and industrial water users prepared Urban

Water Management Plans (UWMPs) that project availability of water supplies to support land uses in 2030. That information was used with projected CVP and SWP water supply availability under each of the alternatives to determine if projected municipal and industrial water demands could be met in 2030 using the CWEST model, as described in Chapter 19, Socioeconomics. The results of the CWEST model indicated that municipal and industrial water demands of CVP and SWP water users in the Central Valley, San Francisco Bay Area, Central Coast, and Southern California regions would be met through a combination of water conservation, available CVP and SWP water supplies, local and regional surface water supplies, groundwater, recycled water, and, in some cases, desalination.

Alternative 4 includes provisions for floodway development regulations. It is assumed that under the No Action Alternative and Alternatives 1 through 5, existing programs to protect floodways would continue to be implemented, including Federal and state requirements as implemented by the U.S. Army Corps of Engineers (USACE), Central Valley Flood Protection Board, and Department of Water Resources (DWR). Within the Delta, the floodways are further regulated by the Delta Protection Commission and Delta Stewardship Council to preserve and protect the natural resources of the Delta; and prevent encroachment into Delta floodways, including the Delta Stewardship Council’s recently adopted Delta Plan. These regulations would continue to be implemented in the No Action Alternative, Alternatives 1 through 5, and the Second Basis of Comparison. Therefore, future development would be prevented from occurring within the Delta floodplains and floodways; and in the Sacramento, Feather, American, and San Joaquin river corridors upstream of the Delta. Provisions in Alternative 4 would require additional setbacks along the floodways as compared to other alternatives and the Second Basis of Comparison. The potential change in land use is analyzed qualitatively in this chapter.

The No Action Alternative, Alternatives 1 through 5, and Second Basis of Comparison include restoration of more than 10,000 acres of intertidal and associated subtidal wetlands in Suisun Marsh and Cache Slough; 17,000 to 20,000 acres of seasonal floodplain restoration in the Yolo Bypass; and continued delivery of refuge water supplies under the Central Valley Project Improvement Act, as described in Chapter 3, Description of Alternatives. Land uses in 2030 due to implementation of these programs would be consistent between all alternatives and the Second Basis of Comparison. Therefore, this EIS does not analyze changes due to these programs.

13.4.1.2 Effects Related to Cross Delta Water Transfers

Cross Delta water transfers involving the CVP and SWP facilities or water supplies would be required to be implemented in accordance with all existing regulations and requirements, including not causing adverse impacts to other water users in accordance with the requirements of Reclamation, DWR, and the State Water Resources Control Board. It is anticipated that water transfers would continue under all alternatives to provide water supplies to agricultural, municipal and industrial, and wildlife refuges under all alternatives and the Second Basis of

Comparison in a similar manner. Transfers for municipal and industrial water users would be one of several water supply sources to meet the future water demands in Year 2030. If the availability of transferred water is reduced, it is anticipated that other water supplies (e.g., recycled water and desalination) would be increased, as described in the UWMPs for 2030 water demands.

Reclamation recently prepared a long-term regional water transfer environmental document which evaluated potential changes in surface water 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. The analysis indicated that water transfers would not result in changes to non-agricultural land uses.

Under all of the alternatives and Second Basis of Comparison, it is assumed that these transfers would continue to occur each year to meet the water demands in the existing general plans. It is not anticipated that water transfers would change municipal and industrial land uses as defined in the existing general plans. If a water transfer program was implemented for the purposes of changing existing general plan land uses, separate environmental documentation would be required for the changes to the general plan and the water transfer. Potential effects due to Cross Delta water transfers on in agricultural land uses are described in Chapter 12, Agricultural Resources. Therefore, this chapter does not include separate analyses of changes in municipal and industrial land uses due to cross Delta water transfers.

13.4.2 Conditions in Year 2030 without Implementation of Alternatives 1 through 5

This EIS includes two bases of comparison (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.

13.4.2.1 No Action Alternative

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. Many of the changed conditions would occur in the same manner under both the No Action Alternative and the Second Basis of Comparison (e.g., climate change, sea level rise, projected development under existing general plans, and implementation of reasonable and foreseeable projects). Due to these changes, especially climate change and sea level rise, it is anticipated that CVP and SWP water supply availability would be less than under recent conditions (described in Chapter 5, Surface Water Resources and Water Supplies). However, it is anticipated that projected land uses would occur by 2030 with implementation of water conservation programs and the development of other water supplies, including ongoing recycled water programs, desalination, and groundwater use.

By 2030 under the No Action Alternative and the Second Basis of Comparison, it is assumed that ongoing programs would result in restoration of more than 10,000 acres of intertidal and associated subtidal wetlands in Suisun Marsh and Cache Slough; and 17,000 to 20,000 acres of seasonal floodplain restoration in the Yolo Bypass.

Under the No Action Alternative and the Second Basis of Comparison, land uses in 2030 would occur in accordance with the general plans for counties and cities within the Central Valley Region; tribal lands; and regulations of state and regional agencies, including Central Valley Flood Protection Board, Delta Protection Commission, and Delta Stewardship Council.

Development along the river corridors in the Central Valley would continue to be limited by the state regulations to protect floodways. The Central Valley Flood Protection Board adopts floodway boundaries and approves uses within those floodways (DWR 2010). Various uses are permitted in the floodways, such as agriculture, canals, low dikes and berms, parks and parkways, golf courses, sand and gravel mining, structures that will not be used for human habitation, and other facilities and activities that will not be substantially damaged by the base flood event and will not cause adverse hydraulic impacts that will raise the water surface in the floodway.

Within the Delta, future development also is subject to the requirements of the Delta Protection Commission and Delta Stewardship Council. The general plans within the Delta are required by state laws to be consistent with the Delta Protection Commission’s *Land Use and Resource Management Plan for the Primary Zone of the Delta* (DPC 2010; OAL 2010), which does not allow development within the Primary Zone of the Delta unless proponents can demonstrate that implementing their projects would preserve and protect natural resources of the Delta, promote protection of remnants of riparian and aquatic habitat, not result in loss of wetlands or riparian habitat, would not degrade water quality, would not interfere with migratory birds or public access, would not harm agricultural operations, and would not degrade levees or expose the public to increased flood hazards. Farmers are encouraged to implement management practices to maximize habitat values for migratory birds and wildlife.

The Delta Plan adopted by the Delta Stewardship Council in May 2013 included a policy that protects floodways within the entire Delta that are not regulated by other Federal or state agencies (23 California Code of Regulations Section 5014). This policy prevents encroachment into floodways that would impede the free flow of water in the floodway or jeopardize public safety.

13.4.3 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 the following alternative analysis:

- 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.

13.4.3.1 No Action Alternative

As described in Chapter 4, Approach to Environmental Analysis, the No Action Alternative is compared to the Second Basis of Comparison.

13.4.3.1.1 Changes in Land Use

No municipal and industrial land uses in the Trinity River Region are served by CVP and SWP water supplies. Therefore, the municipal and industrial land uses would be the same under the No Action Alternative and the Second Basis of Comparison in the Trinity River Region.

As described in Chapter 5, Surface Water Resources and Water Supplies, CVP and SWP water deliveries to municipal and industrial Sacramento River Water Rights Settlement Contractors and water rights holders would be similar under the No Action Alternative and the Second Basis of Comparison. CVP water deliveries to water service contractors over the long-term conditions would be 6 percent less for the North of Delta water users and 10 percent less for the South of Delta users under the No Action Alternative, compared to the Second Basis of Comparison. SWP water deliveries to water contractors over the long-term conditions (without Article 21 water) would be reduced by 18 percent throughout the SWP service area under the No Action Alternative, compared to the Second Basis of Comparison. However, as described in Chapter 19, Socioeconomics, 2030 municipal and industrial water demands would be met through a combination of available CVP and SWP water supplies and other water supplies, including water conservation, water transfers, local and regional surface water and groundwater, recycled water, and desalination. Adequate water supplies would be available to support future municipal and industrial land uses projected in existing general plans under the No Action Alternative and the Second Basis of Comparison. Therefore, land use in 2030 would be the same under the No Action Alternative and the Second Basis of Comparison in the Trinity River, Central Valley, San Francisco Bay Area, Central Coast, and Southern California regions.

13.4.3.2 Alternative 1

Alternative 1 is identical to the Second Basis of Comparison. Alternative 1 is compared to the No Action Alternative and the Second Basis of Comparison. However, because land use conditions under Alternative 1 are identical to land use conditions under the Second Basis of Comparison, Alternative 1 is only compared to the No Action Alternative.

13.4.3.2.1 Alternative 1 Compared to the No Action Alternative

Change in Land Use

No municipal and industrial land uses in the Trinity River Region are served by CVP and SWP water supplies. Therefore, the municipal and industrial land uses would be the same under Alternative 1 and the No Action Alternative in the Trinity River Region.

As described in Chapter 5, Surface Water Resources and Water Supplies, CVP and SWP water deliveries to municipal and industrial Sacramento River Water Rights Settlement Contractors and water rights holders would be similar under Alternative 1 and the No Action Alternative. CVP water deliveries to water service contractors over the long-term conditions would be 7 percent greater for the North of Delta water users and 11 percent greater for the South of Delta users under Alternative 1 as compared to the No Action Alternative. SWP water deliveries to water contractors over the long-term conditions (without Article 21 water) would be increased by 22 percent under Alternative 1 as compared to the No Action Alternative. The increased CVP and SWP water supply availability would allow water users to reduce other water supplies, including groundwater. It is anticipated that the additional water supplies would not result in changes in the general plan development plans without subsequent environmental documentation. Adequate water supplies would be available to support future municipal and industrial land uses projected in existing general plans under Alternative 1 and the No Action Alternative. Therefore, land use in 2030 would be the same under Alternative 1 and the No Action Alternative in the Trinity River, Central Valley, San Francisco Bay Area, Central Coast, and Southern California regions.

13.4.3.2.2 Alternative 1 Compared to the Second Basis of Comparison

Alternative 1 is identical to the Second Basis of Comparison.

13.4.3.3 Alternative 2

The land use conditions under Alternative 2 would be identical to the conditions under the No Action Alternative; therefore, Alternative 2 is only compared to the Second Basis of Comparison.

13.4.3.3.1 Alternative 2 Compared to the Second Basis of Comparison

Changes to land use under Alternatives 2 as compared to the Second Basis of Comparison would be the same as the impacts described in Section 13.4.3.1, No Action Alternative.

13.4.3.4 Alternative 3

The CVP and SWP operations under Alternative 3 are similar to the Second Basis of Comparison with modified Old and Middle River flow criteria and New Melones Reservoir operations.

Alternative 3 would include changed water demands for American River water supplies as compared to the No Action Alternative or Second Basis of Comparison. Alternative 3 would provide water supplies of up to 17 thousand acre feet (TAF)/year under a Warren Act Contract for El Dorado Irrigation District and 15 TAF/year under a CVP water service contract for El Dorado County Water Agency. These demands are not included in the analysis presented in this section of the EIS. A sensitivity analysis comparing the results of the analysis with and without these demands is presented in Appendix 5B of this EIS.

13.4.3.4.1 Alternative 3 Compared to the No Action Alternative

Changes in Land Use

No municipal and industrial land uses in the Trinity River Region are served by CVP and SWP water supplies. Therefore, the municipal and industrial land uses would be the same under Alternative 3 and the No Action Alternative in the Trinity River Region.

As described in Chapter 5, Surface Water Resources and Water Supplies, CVP and SWP water deliveries to municipal and industrial Sacramento River Water Rights Settlement Contractors and water rights holders would be similar under Alternative 3 and the No Action Alternative. CVP water deliveries to water service contractors over the long-term conditions would be similar for the North of Delta water users and 9 percent greater for the South of Delta users under Alternative 3, compared to the No Action Alternative. SWP water deliveries to water contractors over the long-term conditions (without Article 21 water) would be increased by 17 percent under Alternative 3, compared to the No Action Alternative. The increased CVP and SWP water supply availability would allow water users to reduce other water supplies, including groundwater. It is anticipated that the additional water supplies would not result in changes in the general plan development plans without subsequent environmental documentation. Adequate water supplies would be available to support future municipal and industrial land uses projected in existing general plans under Alternative 3 and the No Action Alternative. Therefore, land use in 2030 would be the same under Alternative 3 and the No Action Alternative in the Trinity River, Central Valley, San Francisco Bay Area, Central Coast, and Southern California regions.

13.4.3.4.2 Alternative 3 Compared to the Second Basis of Comparison

Changes in Land Use

No municipal and industrial land uses in the Trinity River Region are served by CVP and SWP water supplies. Therefore, the municipal and industrial land uses would be the same under Alternative 3 and the Second Basis of Comparison in the Trinity River Region.

As described in Chapter 5, Surface Water Resources and Water Supplies, CVP and SWP water deliveries to municipal and industrial Sacramento River Water Rights Settlement Contractors and water rights holders would be similar under Alternative 3 and the Second Basis of Comparison. CVP water deliveries to water service contractors over the long-term conditions would be similar for the North of Delta water users and South of Delta users under Alternative 3 and the Second Basis of Comparison. SWP water deliveries to water contractors over the long-term conditions (without Article 21 water) would be similar under Alternative 3 and the Second Basis of Comparison. Adequate water supplies would be available to support future municipal and industrial land uses projected in existing general plans under Alternative 3 and the Second Basis of Comparison. Therefore, land use in 2030 would be the same under Alternative 3 and the Second Basis of Comparison in the Trinity River, Central Valley, San Francisco Bay Area, Central Coast, and Southern California regions.

13.4.3.5 Alternative 4

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. Under Alternative 4, new development and substantial improvements would be prohibited within floodways or within 170 feet of the ordinary high water line of any floodway.

13.4.3.5.1 Alternative 4 Compared to the No Action Alternative

Changes in Land Use

The CVP and SWP operations under Alternative 4 are identical to the CVP and SWP operations under Alternative 1. Therefore, the land use conditions influenced by availability of CVP and SWP water supplies under Alternative 4 would be the same as conditions under Alternative 1.

Under Alternative 4, new development and substantial improvements would be prohibited within floodways or within 170 feet of the ordinary high water line of any floodway. Development within floodways is currently prohibited in accordance with existing general plans and state and regional plans (e.g., requirements of the Delta Protection Commission and Delta Stewardship Council). Structures that either cannot be moved before flood events or that would reduce the flood management function of the floodway are not allowed. It is anticipated that these requirements would continue to be implemented in 2030, to protect the floodways. However, Alternative 4 would include additional restrictions on new development within 170 feet of the ordinary high water line of any floodway. It is anticipated that the provisions under Alternative 4 could result in site-specific parcel changes as compared to the No Action Alternative. However, the development that would have occurred on these parcels could be incorporated within the general plan development plans and guidelines. Therefore, land use conditions under Alternative 4 would be similar to conditions under the No Action Alternative; and would be the same as the impacts described in Section 13.4.3.2.1, Alternative 1 Compared to the No Action Alternative.

13.4.3.5.2 Alternative 4 Compared to the Second Basis of Comparison

Changes in Land Use

The CVP and SWP operations under Alternative 4 are identical to the CVP and SWP operations under Second Basis of Comparison. Therefore, the land use conditions influenced by availability of CVP and SWP water supplies under Alternative 4 would be the same as conditions under the Second Basis of Comparison.

Under Alternative 4, new development and substantial improvements would be prohibited within floodways or within 170 feet of the ordinary high water line of any floodway. Development within floodways is currently prohibited in accordance with existing general plans and state and regional plans (e.g., requirements of the Delta Protection Commission and Delta Stewardship Council). Structures that either cannot be moved prior to flood events or that would reduce the flood management function of the floodway are not allowed. It is anticipated that these requirements would continue to be implemented in 2030 to protect the floodways. However, Alternative 4 would include additional restrictions on new development within 170 feet of the ordinary high water line of any floodway. It is anticipated that the provisions under Alternative 4 could result in site-specific parcel changes as compared to the Second Basis of Comparison. However, the development that would have occurred on these parcels could be incorporated within the general plan development plans and guidelines. Therefore, land use conditions under Alternative 4 would be identical to conditions under the Second Basis of Comparison.

13.4.3.6 Alternative 5

The 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.

Alternative 5 would include changed water demands for American River water supplies as compared to the No Action Alternative or Second Basis of Comparison. Alternative 5 would provide water supplies of up to 17 TAF/year under a Warren Act Contract for El Dorado Irrigation District and 15 TAF/year under a CVP water service contract for El Dorado County Water Agency. These demands are not included in the analysis presented in this section of the EIS. A sensitivity analysis comparing the results of the analysis with and without these demands is presented in Appendix 5B of this EIS.

13.4.3.6.1 Alternative 5 Compared to the No Action Alternative

Changes in Land Use

No municipal and industrial land uses in the Trinity River Region are served by CVP and SWP water supplies. Therefore, the municipal and industrial land uses would be the same under Alternative 5 and the No Action Alternative in the Trinity River Region.

As described in Chapter 5, Surface Water Resources and Water Supplies, CVP and SWP water deliveries to municipal and industrial Sacramento River Water Rights Settlement Contractors and water rights holders would be similar under Alternative 5 and the No Action Alternative. CVP water deliveries to water service contractors over the long-term conditions would be similar for the North of Delta and South of Delta water users under Alternative 5, compared to the No Action Alternative. SWP water deliveries to water contractors over the long-term conditions (without Article 21 water) would be similar under Alternative 5, compared to the No Action Alternative. Adequate water supplies would be available to support future municipal and industrial land uses projected in existing general plans under Alternative 5 and the No Action Alternative. Therefore, land use in 2030 would be the same under Alternative 5 and the No Action Alternative in the Trinity River, Central Valley, San Francisco Bay Area, Central Coast, and Southern California regions.

13.4.3.6.2 Alternative 5 Compared to the Second Basis of Comparison

Changes in Land Use

No municipal and industrial land uses in the Trinity River Region are served by CVP and SWP water supplies. Therefore, the municipal and industrial land uses would be the same under Alternative 5 and the Second Basis of Comparison in the Trinity River Region.

As described in Chapter 5, Surface Water Resources and Water Supplies, CVP and SWP water deliveries to municipal and industrial Sacramento River Water Rights Settlement Contractors and water rights holders would be similar under the No Action Alternative and the Second Basis of Comparison. CVP water deliveries to water service contractors over the long-term conditions would be similar for the North of Delta water users and 10 percent less for the South of Delta water users under Alternative 5 as compared to the Second Basis of Comparison. SWP water deliveries to water contractors over the long-term conditions (without Article 21 water) would be reduced by 19 percent throughout the SWP service area under the Alternative 5, compared to the Second Basis of Comparison. However, as described in Chapter 19, Socioeconomics, 2030 municipal and industrial water demands would be met through a combination of available CVP and SWP water supplies and other water supplies, including water conservation, water transfers, local and regional surface water and groundwater, recycled water, and desalination. Adequate water supplies would be available to support future municipal and industrial land uses projected in existing general plans under Alternative 5 and the Second Basis of Comparison. Therefore, land use in 2030 would be the same under Alternative 5 and the Second Basis of Comparison in the Trinity River, Central Valley, San Francisco Bay Area, Central Coast, and Southern California regions.

13.4.3.7 Summary of Impact Analysis

The results of the environmental consequences of implementation of Alternatives 1 through 5, compared to the No Action Alternative and the Second Basis of Comparison are presented in Tables 13.1 and 13.2.

Table 13.1 Comparison of Alternatives 1 through 5 to No Action Alternative

Alternative	Potential Change	Consideration for Mitigation Measures
Alternative 1	No effects to municipal and industrial and regional land uses	None needed
Alternative 2	No effects to municipal and industrial and regional land uses	None needed
Alternative 3	No effects to municipal and industrial and regional land uses	None needed
Alternative 4	No effects to municipal and industrial and regional land uses	None needed
Alternative 5	No effects to municipal and industrial and regional land uses	None needed

Table 13.2 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	No effects to municipal and industrial and regional land uses	None needed
Alternative 1	No effects to municipal and industrial and regional land uses	None needed
Alternative 2	No effects to municipal and industrial and regional land uses	None needed
Alternative 3	No effects to municipal and industrial and regional land uses	None needed
Alternative 4	No effects to municipal and industrial and regional land uses	None needed
Alternative 5	No effects to municipal and industrial and regional land uses	None needed

13.4.3.8 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.

Changes in CVP and SWP operations under Alternatives 1 through 5, compared to the No Action Alternative, would not result in changes in municipal and industrial land uses or regional lands use plans. Therefore, there would be no adverse impacts to land use and no mitigation measures are required.

13.4.3.9 Cumulative Effects Analysis

As described in Chapter 3, Description of Alternatives, 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 Land Use are summarized in Table 13.3.

Table 13.3 Summary of Cumulative Effects on Land Use with Implementation 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 all Alternatives in Year 2030	Consistent with Affected Environment conditions plus: 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 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): - 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 - General plans for 2030. - Trinity River Restoration Program. - Central Valley Project Improvement Act programs - Iron Mountain Mine Superfund Site - Nimbus Fish Hatchery Fish Passage Project - Folsom Dam Water Control Manual Update - FERC Relicensing for the Middle Fork of the American River Project - Lower Mokelumne River Spawning Habitat Improvement Project - Dutch Slough Tidal Marsh Restoration - Suisun Marsh Habitat Management, Preservation, and Restoration Plan Implementation - Tidal Wetland Restoration: Yolo Ranch, Northern Liberty Island Fish	<u>These effects would be the same under all alternatives.</u> Community development would occur in accordance with general plan projections for 2030. Development within the Delta would be subject to the requirements of the Delta Protection Commission and Delta Stewardship Council. Restoration plans for the ongoing programs would be completed. Development along river corridors in the Central Valley would continue to be limited by the state regulations to protect floodways. 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 as compared to past conditions. Future water supply projects are anticipated to both increase water supply reliability due to reduced 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.

Scenarios	Actions	Cumulative Effects of Actions
	Restoration Project, Prospect Island Restoration Project, and Calhoun Cut/Lindsey Slough Tidal Habitat Restoration Project - San Joaquin River Restoration Program - Future water supply projects, including water recycling, desalination, groundwater banks and wellfields, and conveyance facilities (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): - Bay-Delta Water Quality Control Plan Update - FERC Relicensing Projects - Bay Delta Conservation Plan(including the California WaterFix alternative) - Shasta Lake Water Resources, North-of-the-Delta Offstream Storage, Los Vaqueros Reservoir Expansion Phase 2, and Upper San Joaquin River Basin Storage Investigations - El Dorado Water and Power Authority Supplemental Water Rights Project - Sacramento River Water Reliability Project - Semitropic Water Storage District Delta Wetlands - North Bay Aqueduct Alternative Intake - San Luis Reservoir Low Point Improvement Project - 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 under all alternatives.</u> Most of the 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. Some of the 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.

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 BO	Community development would occur in accordance with general plan projections for 2030. Development within the Delta would be subject to the requirements of the Delta Protection Commission and Delta Stewardship Council. Restoration plans for the ongoing programs would be completed. Development along river corridors in the Central Valley would continue to be limited by the state regulations to protect floodways. Climate change and sea level rise, 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 as compared to past conditions. Future water supply projects are anticipated to both increase water supply reliability due to reduced surface water supplies and to accommodate planned growth in the general plans.
Alternative 1 reasonably foreseeable 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 reasonably foreseeable actions would result in similar changes as under the No Action Alternative with the added actions.
Alternative 2 reasonably foreseeable actions in Year 2030	Full implementation of the 2008 USFWS BO and 2009 NMFS BO CVP and SWP operational actions 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 similar changes as under the No Action Alternative with the added actions.
Alternative 3 reasonably foreseeable 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) Slight increase in positive Old and Middle River flows in the winter and spring months	Implementation of Alternative 3 with reasonably foreseeable actions would result in similar changes as under the No Action Alternative with the added actions.

Scenarios	Actions	Cumulative Effects of Actions
Alternative 4 reasonably foreseeable 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) Increased restrictions for development within floodways.	Implementation of Alternative 4 with reasonably foreseeable actions would result in similar changes as under the No Action Alternative with the added actions.
Alternative 5 reasonably foreseeable actions in Year 20530	Full implementation of the 2008 USFWS BO and 2009 NMFS BO 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 changes as under the No Action Alternative with the added actions.

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Chapter 14

Visual Resources

14.1 Introduction

This chapter describes the visual resources in the study area related to natural and artificial landscape features and potential changes that could occur as a result of implementing the alternatives evaluated in this Environmental Impact Statement (EIS). Implementation of the alternatives considered in this EIS could affect visual resources through changes in surface water elevations at Central Valley Project (CVP) and State Water Project (SWP) reservoirs and changes in land use related to potential changes in operation of the CVP and SWP and ecosystem restoration.

Changes in reservoir surface water elevations, agricultural resources, and land use are described in more detail in Chapter 5, Surface Water Resources and Water Supplies; Chapter 12, Agricultural Resources; and Chapter 13, Land Use, respectively.

14.1.1 Visual Effects

Natural and artificial landscape features contribute to perceived visual images and aesthetic values of views. The values of views frequently are determined by contrasts of forms and textures related to geology, hydrology, vegetation and wildlife, agricultural crops, and other land uses. For example, a small water feature in a plain may be a significant visual feature; however, a small water feature within an area with vast rivers or larger ponds may be of less significance.

Visual effects are dependent upon the viewpoint of individuals because each person can respond differently to changes in the physical environment depending upon expectations, historical perspective, duration and frequency of the views, and extent of a viewshed. A viewshed is defined by the Federal Highway Administration (DOT 1981) as a surface area visible from a particular location. The character of a viewshed can also vary daily, seasonally, and with changing weather.

Visual effects also are affected by the general activities of the viewers. Passengers in automobiles and trains with relatively short exposure to views may have a different experience than recreationists or residents who view the area for longer periods of time. Residents and recreationists frequently select a location for their activities due to the views. Changes in views could affect the quality of their activities, including housing, camping, hiking, or boating locations. Therefore, changes in visual effects are dependent upon the visual quality of the landscape within the context of the setting (DOT 1981).

Visual quality, or scenic value, has been classified with respect to the lines, forms, colors, textures, and composition of landforms, vegetation, rocks, cultural features, and water features by the U.S. Department of Agriculture (USDA), Forest Service (USDA 1995). The classification system includes Class A, Distinctive; Class B, Typical (or ordinary or common features); and Class C, Indistinctive. This classification system also considers the scenic integrity, or the completeness of the landscape character.

14.2 Regulatory Environment and Compliance Requirements

Potential actions that could be implemented under the alternatives evaluated in this EIS could affect visual resources at reservoirs 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 Analysis.

14.3 Affected Environment

This section describes visual resources that could be potentially affected by the implementation of the alternatives considered in this EIS. Changes in visual resources 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.

Physical form and visual character are the result of the interaction of natural and engineered elements. Natural elements, including topography, hydrology, vegetation, and climate create the physical context. Engineered elements, such as buildings, roads, infrastructure, and settlement patterns, are secondary elements that act on the natural physical context to establish a visual environment.

Both the natural and engineered landscape features contribute to perceived views and the aesthetic value of those views. In areas considered to have high resource value and scenic character, it is important to evaluate and protect the visual character and aesthetic value of landscapes that may to undergo alteration.

14.3.1 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.

14.3.1.1 Trinity River Watershed

The Trinity River drains an area of the Coast Range, northwest of the Sacramento Valley. Dams on the river form Trinity Lake and Lewiston Lake, both of which are in the Whiskeytown-Shasta-Trinity National Recreation Area, as described in Chapter 15, Recreation Resources. The Trinity River flows through sparsely populated and heavily forested, mountainous terrain, jagged cliffs that can be viewed during numerous recreational opportunities, including fishing, rafting, kayaking, and canoeing. The forests offer visual resources which include snow-covered peaks, volcanoes, rock outcroppings, mountain creeks, lakes, meadows, and a wide variety of trees and vegetation. Downstream of Lewiston Dam, the Trinity River corridor is characterized by gravel bars, riparian vegetation, and human-built features (NCRWQCB et al. 2009). Artificial lights occur related to passing vehicles and local residential and commercial buildings. Glare related to the water surfaces may occur from some view locations.

14.3.1.1.1 Wild and Scenic Rivers and Scenic Highways in the Trinity River Watershed

On January 19, 1981, the Secretary of the Interior designated portions of the Trinity River watershed as part of the National Wild and Scenic Rivers System, including the Trinity River downstream of Lewiston Dam, and portions of the South Fork, North Fork, and New River (BLM et al. 2012). The State of California adopted similar reaches as wild and scenic under Public Resources Code sections 5093.54 and 5093.545.

The Trinity River Region includes two highways in Trinity County and one highway in Humboldt County that are eligible for State Scenic Highway designations. The two highways in Trinity County are eligible for State Scenic Highway designation and include the Siskiyou-Trinity Scenic Byway (State Route 3, which extends from south of Hayfork to north of Trinity Lake to Interstate 5) and Trinity Scenic Byway (State Route 299, which extends from the Pacific Ocean to Redding) (CalTrans 2014a). In Humboldt County, State Route 96 along the Trinity River from Willow Creek to the confluence with the Klamath River is eligible for State Scenic Highways designation (CalTrans 2014b).

14.3.1.2 Lower Klamath River Watershed

The Klamath River from the confluence with the Trinity River to the Pacific Ocean is characterized by a forested river canyon with riparian vegetation along the river. Reduced flows in the summer have frequently resulted in algal blooms which has reduced water clarity and visual quality of the river corridor (DOI and DFG 2012).

14.3.1.2.1 Wild and Scenic Rivers and Scenic Highways in the Klamath River Watershed

The portion of the Klamath River watershed within the Trinity River Region considered in this EIS (from the confluence with the Trinity River to the Pacific Ocean) was designated as part of the entire reach of the Klamath River from Iron Gate to the Pacific Ocean by the Secretary of the Interior to be part of the National Wild and Scenic Rivers System on January 19, 1981. The State of California also adopted this reach of Klamath River as wild and scenic under Public Resources Code sections 5093.54 and 5093.545.

Caltrans has not designated highways within the Klamath River watershed in the Trinity River Region as Scenic Highways or identified roadways to be eligible for Scenic Highways status (CalTrans 2014b, 2014c).

14.3.2 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.

The Central Valley Region is predominantly made up of lowlands and plains surrounded by foothills and tall mountains of the Coast Range to the west, the Cascade Range to the north, the Sierra Nevada to the east, and the Tehachapi Mountains to the south. Communities and roadways of various sizes are located throughout the valley. Land use outside of the communities is primarily agricultural, with riparian, wetland and oak woodlands along the major waterways.

14.3.2.1 Sacramento Valley

The Sacramento Valley extends from the northern mountainous areas to the less dramatic landscapes of the Central Valley at the lower elevations. The mountainous areas are characterized by rugged and deep river canyons and valleys that extend from jagged peaks to forested areas with pine and deciduous trees. Large rivers flow from the mountain areas through the foothills into the agricultural areas and communities along the valley floor. Oak woodlands are located at middle and lower elevations of the foothills and along riparian corridors on the valley floor.

The Sacramento Valley extends from Shasta Lake and Whiskeytown Lake to the Delta. The Sacramento Valley portion of the Central Valley Region considered in this EIS includes the middle and lower portions of the Feather River and American River watersheds that are influenced by CVP and SWP water supply facilities, respectively.

14.3.2.1.1 Shasta Lake, Keswick Reservoir, and Whiskeytown Lake

Shasta Lake, Keswick Reservoir, and Whiskeytown Lake are in the Whiskeytown-Shasta-Trinity National Recreation Area, as described in Chapter 15, Recreation Resources. These watersheds provide opportunities for high quality visual attractions, such as mountains, forests, waterfalls, streams, open water, and vistas of the sky that can be experienced during numerous recreational activities such as boating, water skiing, swimming, fishing, camping, picnicking, hiking, hunting, and mountain biking. Panoramic views for travelers through the area can be seen from many locations, including State Route 151 vista point, Shasta Dam Visitor Center, and Interstate 5. The contrast between the open water bodies and surrounding mountains provides a wide diversity of views. The quality and diversity of visual resources at the lakes and the surrounding areas is influenced by human-built features such as highways, railroads, resorts, bridges, communities, and electrical transmission facilities. The visual quality of open waters also is influenced by fluctuating water levels. Typically, the water levels decline from an annual maximum in May to a minimum in October. In extremely dry years, exposed bare mineral soils in a “bathtub ring” are in substantial contrast to the open water and the upslope vegetation (Reclamation 2013a).

Between the lakes, pine and oak forests predominate, with intermittent chaparral and rock outcrops. The landscape includes mountain ranges, volcanoes, and waterways, opening below the reservoir to the agricultural vistas and communities of the Central Valley.

14.3.2.1.2 Sacramento River Watershed: Keswick Reservoir to Feather River

The scenic qualities of the upper reaches of the Sacramento River watershed south of Keswick Reservoir are generally considered to be of high quality, especially in areas where little to no development has occurred. Varied topography, geologic formations, and natural and manmade water bodies provide striking vistas. Similar conditions are found in the Sierra Nevada Mountains and foothills near the upper and middle Feather, Yuba, American, Mokelumne, Calaveras, and Stanislaus rivers watersheds.

The foothills provide views of rolling hills, open grasslands, and scattered oak and pine woodlands. In the lower elevations of the Central Valley, the human-built environment becomes more dominant, and detracts from views of the natural landscape. Outside of the urban and suburban areas, land use is rural in character, with agricultural areas that include irrigated row crops, orchards, and grazing lands. Sporadically, flooded agricultural fields, especially rice fields managed for wetlands, are used heavily by migrating birds.

Between the Keswick Reservoir and Feather River confluence with the Sacramento River, the landscape also includes human-built reservoirs and canals. Black Butte Reservoir is operationally integrated with the CVP, and the canal system includes the CVP Corning Canal, Tehama-Colusa Canal, and Glenn-Colusa Irrigation District’s canal. The canals provide visual interest in localized areas with limited viewing opportunities (Reclamation 1997).

Visual resources that could be affected in the Feather River and American River watersheds are described below. The remaining portions of the Sacramento Valley between the Feather River and the San Francisco Bay Area Region includes the Delta (described in following subsections of this chapter) and areas located to the east and west of the Delta. Land uses located to the south of the Feather River and outside of the Delta include agricultural, open space, and major urban centers that all use SWP water supplies. The urban areas include the cities of Vacaville, Fairfield, and Vallejo in Solano County and unincorporated areas of Napa County.

Scenic Highways in the Sacramento River Area

In the Sacramento Valley portion of the Central Valley Region, there are several designated State Scenic Highways and several roads that are eligible for this designation, including the following roadways:

- Shasta County: State Route 151 from Shasta Dam to Lake Boulevard is designated as a State Scenic Highway due to views of the Sacramento River, Shasta Lake, and distant hills. State Routes 299, 44, and 89 are eligible for State Scenic Highway designation (CalTrans 2014a, 2014d).

- Tehama County: State Routes 89 and 36 are eligible for State Scenic Highway designation (CalTrans 2014e).
- Yolo County: A portion of State Route 16 is eligible for State Scenic Highways designation (CalTrans 2014f).
- Solano County: A portion of State Route 37 is eligible for State Scenic Highways designation (CalTrans 2014g).
- Napa County: Portions of State Routes 29 and 121 are eligible for State Scenic Highways designation (CalTrans 2014h).

14.3.2.1.3 Feather River Watershed

Antelope Lake, Lake Davis, Frenchman Lake, Lake Oroville, and Thermalito Afterbay on the Feather River are human-built reservoirs providing visual contrast with surrounding terrain.

Upper Feather River

Antelope Lake, Lake Davis, and Frenchman Lake are located in the upper Feather River watershed (DWR 2013a; USFS 2006a, 2006b, 2011). Antelope Lake, located on Indian Creek, has the longest dam of the three reservoirs. This remote lake, surrounded by pine and fir trees, can be viewed from Fruit Growers Boulevard and Indian Creek Road. Lake Davis is formed by Grizzly Dam on Big Grizzly Creek, and is the largest of the three dams. It is located in the upper watershed surrounded by many trees, and can be viewed from Beckwourth-Taylorsville Road and Lake Davis Road. Frenchman Lake, located on Last Chance Creek, is formed by the tallest dam of the three dams. This lake also is surrounded by trees to the waterline and can be viewed from Little Last Chance Creek Road and Frenchman Lake Road.

Lake Oroville and Thermalito Reservoir

The terrain adjacent to Lake Oroville is generally quite steep with limited vehicular access. Most views of the water are from the bridges on State Route 162, State Route 70, and several county roads. Some residents live in the lands around Lake Oroville and Thermalito Afterbay. The residents can easily view the water and visitors can view the structures. As described above for Shasta Lake and other reservoirs in the upper Sacramento River watershed, Lake Oroville water levels decline as summer progresses, leaving a ring of bare soil along the water’s edge. In extremely dry years at Lake Oroville, more than 200 vertical feet of bare mineral soils in a “bathtub ring” may be exposed when the surface water elevation approaches 710 feet above mean sea level (DWR 2007).

The Diversion Pool between Oroville Dam and Thermalito Diversion Dam extends about 4.5 miles along the Feather River and meanders through hillsides with substantial vegetation within widths ranging from 50 to 200 feet (DWR 2007). Vistas of the Diversion Pool are primarily viewed by recreationists on the water or along the adjacent trails. A 1.9-mile-long concrete Thermalito Power Canal appears as a contrast from State Route 70 and county roads to the undeveloped landscape between the Diversion Dam and the Thermalito Forebay.

The Thermalito Forebay is a 630-acre reservoir, approximately 3 miles in length that can be viewed by recreationists along or within the open water and travelers along State Route 70 as the roadway extends from the foothills to the valley floor. Water levels in these human-built features generally vary by 2 to 4 feet during a week. When the water levels are low, exposed bare soils create a "bathtub ring" effect.

Thermalito Afterbay is located in a more flat terrain than Lake Oroville and can be viewed from many locations and residences. The Thermalito Afterbay Dam is located parallel to State Route 99 and rises over 30 feet above the roadway (DWR 2007). The Thermalito Afterbay is approximately 4,300 acres and is visible from State Route 162, several county roads, recreation areas, and neighboring residences. Because the afterbay is located on flat lands with minimal foothills, vistas from the water or lands surrounding the afterbay extend from the Sierra Nevada foothills to the Feather River on the valley floor. Water levels in the afterbay generally vary by 2 to 6 feet during a week, but can decline by as much as 11 feet. When the water levels are low, exposed bare soils create a "bathtub ring" effect.

The low flow channel of the Feather River extends from the Diversion Dam through the community of Oroville (DWR 2007). Urban land uses and other buildings, including the Feather River Fish Hatchery, are located along the channel upstream of the State Route 70 bridge. The Oroville Wildlife Area extends from State Route 70 on the east, downstream of the bridge, and includes the Thermalito Afterbay area. Dredge tailings from hydraulic mining that occurred over 100 years ago occur along the low flow channel with some of the tailings reaching heights of more than 40 feet above the roadway.

Wild and Scenic Rivers and Scenic Highways in the Feather River Watershed

Within the Central Valley Region considered in this EIS, the Middle Fork Feather River (from Beckworth to Lake Oroville) was designated as part of Public Law 90-542 (Wild and Scenic Rivers Act) to be part of the National Wild and Scenic Rivers System on October 2, 1968.

In the Feather River watershed and adjacent Bear River watershed of the Central Valley Region, there is one designated State Scenic Highway and several roads that are eligible for this designation, including the following roadways.

- Butte County: State Route70 is eligible for State Scenic Highways designation (CalTrans 2014i).
- Plumas County: State Routes 70 and 89 are eligible for State Scenic Highways designation (CalTrans 2014j).
- Nevada County: State Route 20 from Skillman Flat Campground to half-mile east of Lowell Hill Road is designated as a State Scenic Highway and a U.S. Forest Service (USFS) Scenic Byway due to views of pine forests and results of hydraulic mining. Interstate 80 and State Routes 20, 49, and 174 are eligible for State Scenic Highways designation (CalTrans 2014k).

14.3.2.1.4 Yuba River Watershed

The middle and lower Yuba River watershed extends through Nevada and Yuba counties. Upstream of New Bullards Bar Reservoir, the watershed is characterized by coniferous, mixed conifer/hardwood, and ponderosa pine forests along steep canyons. Most of the upper watershed is undeveloped with rural communities located along State Route 49 (DWR et al. 2007).

New Bullards Bar Reservoir, on the Yuba River and in Yuba County, is a human built reservoir providing visual contrast of the lake surface with mountainous landscape with conifers and mixed hardwood forests (DWR et al. 2007). There are many locations in the watershed to view the lake and the adjacent forests. Recreational developments are located near the marina and campgrounds near the shoreline.

Downstream of New Bullards Bar Reservoir along the Middle Yuba River and to Englebright Reservoir (located in Nevada and Yuba counties), the landscape is characterized by rolling hills with hardwood and coniferous trees and grasslands (DWR et al. 2007, USACE 2012). This portion of the watershed is rural with communities located along State Route 20.

Downstream of Englebright Reservoir, the landscape includes grasslands and agricultural fields with several small communities (USACE 2012). Along the river, the landscape is dominated by remnants of historic gold and gravel mining and ongoing gravel mining activities with minimal riparian vegetation. This portion of the watershed can be viewed from State Route 20.

14.3.2.1.5 Middle and Lower American River Watershed

The middle and lower American River watershed extends through Placer, El Dorado, and Sacramento counties. Upstream of Folsom Dam, much of Placer and El Dorado counties are characterized by undeveloped rolling grasslands and oak woodlands with sporadic agricultural activities related to orchards, vineyards, ornamental flowers, and Christmas tree farms in the wooded foothills. Communities have been developed throughout the counties especially near Interstate 80, U.S. Highway 50, and State Routes 49 and 89.

Folsom Lake, on the American River, is a human built reservoir providing visual contrast with the foothill landscape. Views from the water surface provide panoramic vistas of the foothills with open grasslands, oak woodlands, and pine woodlands. Folsom Lake is generally considered to provide a pleasing visual setting for recreationists, residences, and from roadways along the foothills above the reservoir, especially from the Lake Overlook and the Folsom Dam Observation Point vista points. Increased population in the communities around the lake have provided more scenic view points, including increased vistas of human-built structures such as electric transmission facilities, roadways, dams, and residential subdivisions. Reservoir levels fluctuate and decline as summer progresses, leaving a “bathtub ring” of bare soil along the water’s edge. The visual quality also degrades because visitors drive vehicles onto the exposed soils which cause tire tracks and erosion (Reclamation et al. 2006).

Lake Natoma extends from Folsom Dam along the American River to Nimbus Dam. The land along the river is mostly undeveloped and includes wooded canyon areas, sheer bluffs, and dredge tailings from the gold mining era. Residential and community developments have been constructed along the foothills that overlook the canyon, and these structures can be seen by recreationists from the water or adjacent trails. Lake Natoma can be viewed from U.S. Highway 50 and local roads.

Downstream of Nimbus Dam to Gristmill Recreation Area (downstream of William B. Pond Recreation Area and approximately 2 miles upstream from the Watt Avenue Bridge), the American River flows through a landscape characterized by steep bluffs, terraces, mid-river sand and gravel bars, backwater areas along the edges, and riparian vegetation. This viewshed is seen from the recreational areas on the water and adjoining trails, from the bridge crossings, and from residences along the terraces and foothills. Downstream of the Gristmill Dam Recreation Area, the visual characteristics are less complex with an increased number of bridges, water treatment plant intake, and artificial bank protection. The communities along the American River corridor include the cities of Folsom, Roseville, Rancho Cordova, and Sacramento and unincorporated areas. The communities, transportation infrastructure, and water-river corridor are visible from multiple vantage points.

Wild and Scenic Rivers and Scenic Highways in the American River Watershed

Within the American River watershed, the Lower American River from Nimbus Dam to the confluence with the Sacramento River were designated by the Secretary of the Interior to be part of the National Wild and Scenic Rivers System on January 19, 1981. The State of California also designated the Lower American River as wild and scenic under Public Resources Code sections 5093.54 and 5093.545. In addition, the state designated the North Fork American River from the source to Iowa Hill Bridge as wild and scenic.

In the portion of the American River watershed in the study area of this EIS, there is one roadway designated as a State Scenic Highway and one road that is eligible for this designation. In El Dorado County, U.S. Highway 50 from Government Center Interchange in Placerville to South Lake Tahoe is designated as a State Scenic Highway due to vistas of the American River canyon, suburban foothills, granite peaks, and Lake Tahoe. Also in El Dorado County, State Route 49 is eligible for State Scenic Highways designation (CalTrans 2014l).

14.3.2.2 San Joaquin Valley

The San Joaquin Valley land cover ranges from high alpine vegetation near the crest of the Sierra Nevada Mountains, through coniferous forest, mixed forest, oak woodlands and oak savanna, to grasslands and agricultural areas at the lower elevations (Reclamation 1997, 2005a, 2005b). Water bodies include reservoirs, natural lakes and ponds, rivers, and tributary streams. The human-built environment is more dominant at lower elevations, and includes roadways, communities, roadside businesses, and transmission lines, detracting from views of the natural environment. On the valley floor, the San Joaquin Valley is characterized by agricultural lands, including many that are irrigated with CVP and/or SWP water supplies. The valley is arid to semi-arid, and there are few natural lakes or streams on the valley floor.

Several wetlands have been established as wildlife refuges in the San Joaquin Valley (as described in Chapter 10, Terrestrial Biological Resources), providing views of water and vegetation, enhanced seasonally by waterfowl and seasonal wildflowers.

The predominant land use is agricultural, with sparse to moderate populations. Interstate 5 and major railroads pass along the western San Joaquin Valley at the base of the Coast Ranges foothills. State Route 99 and other railroads are located along the eastern San Joaquin Valley at the base of the Sierra Nevada foothills. Interstate 580 and State Routes 152, 198, and 46 cross the San Joaquin Valley from east to west between Interstate 5 and State Route 99. Larger cities have been established in the northern San Joaquin Valley, including Lodi, Stockton, Lathrop, Manteca, and Tracy; and along State Route 99, including Merced, Fresno, Visalia, and Bakersfield. Both Interstate 5 and State Route 99 are extensively traveled and provide numerous viewing opportunities.

14.3.2.2.1 Northern San Joaquin Valley

In the northern San Joaquin Valley, the foothills range from rolling hills to mountainous terrain with riparian corridors that range from narrow canyons to alluvial plains. The San Joaquin, Stanislaus, Merced, and Tuolumne rivers are the principal water features that flow from the Sierra Nevada foothills. One or more reservoirs are located along each of these rivers, including the CVP New Melones Reservoir on the Stanislaus River and Millerton Lake on the San Joaquin River. Other reservoirs are owned and operated by local and regional water suppliers, as described in Chapter 5, Surface Water Resources and Water Supplies. Dredge tailings have been deposited along some of the rivers as the streams flow from the mountains into the foothills.

The CVP New Melones Reservoir is located in the western foothills of the Sierra Nevada along the Stanislaus River. The area is characterized by foothills, ridges, and small valleys with vegetated slopes and the open water surface (Reclamation 2010). The vegetation is primarily grasslands and oak woodlands with varying densities, with gray pine and low shrubs along some slopes. Views of the water are primarily from the water surface, adjacent recreation areas, and State Route 49. The surrounding lands are rural and undeveloped except for the infrastructure associated with the dam, canals, and power generation facilities and some minor structures associated with the recreation areas and utility lines. When the reservoir is drawn down, broad bands of bare soil are exposed.

Millerton Lake also is located in the western foothills of the Sierra Nevada along the San Joaquin River in an area that ranges from grasslands and rolling hills near Friant Dam to steep, craggy slopes in the upper reaches of the lake (Reclamation et al. 2011a). The lake, dam infrastructure, and surrounding hills can be viewed from the lake surface and adjacent county roads. Development has occurred along the hillsides that can be viewed from the lake surface and adjacent recreation areas; however; future development will be regulated by Madera and Fresno counties to protect visual and scenic resources. When the reservoir is drawn down, broad bands of bare soil are exposed. The Madera Canal and Friant-Kern Canal extend from Millerton Lake to the north and south, respectively. The canals are located along the Sierra Nevada foothills through mostly agricultural landscapes and limited residences (Reclamation et al. 2011, Reclamation 1997). The canals are only intermittently visible from county roads.

14.3.2.2.2 Western San Joaquin Valley

The Coast Range foothills on the western side of the northern San Joaquin Valley are sparsely populated and characterized by mountainous to hilly terrain with grasslands and scattered oak woodlands along narrow streams. The CVP and SWP San Luis Reservoir complex is located within the western foothills; and the CVP and SWP water supply canals are located at the base of the foothills to the north and south of the San Luis Reservoir.

The CVP and SWP water supply facilities are prominent features in the viewshed of the San Joaquin Valley, including facilities at or near San Luis Reservoir, Delta-Mendota Canal, San Luis Canal-California Aqueduct, Cross Valley Canal, New Melones Reservoir, and Millerton Lake. The San Luis Reservoir, O’Neill Forebay, and Los Banos Creek Reservoir are located in northwestern San Joaquin Valley. State Route 152 is located along the northern and eastern rims of San Luis Reservoir and the western rim of O’Neill Forebay (Reclamation and State Parks 2013). O’Neill Forebay and Los Banos Creek Reservoir can be seen to the west from Interstate 5. The reservoirs are also part of the visual resources for the San Luis Reservoir State Recreation Area, Pacheco State Park, and Upper and Lower Cottonwood Wildlife Areas (which are described in Chapter 10, Terrestrial Biological Resources, and Chapter 15, Recreation Resources). The shorelines of the reservoirs are undeveloped, except for recreational facilities. Views included annual grassland, coastal sage, and riparian woodland. When the reservoirs are drawn down, broad bands of bare soil are exposed. Open water viewing opportunities also occur to the south of the San Luis complex at the Little Panoche Reservoir located to the west of Interstate 5.

The open water and canal infrastructure of the Delta-Mendota Canal, San Luis Canal-California Aqueduct, Cross Valley Canal, and irrigation district canals can be viewed from Interstate 5 and the railroad lines along the western San Joaquin Valley. The open water of Mendota Pool is located at the terminus of the Delta Mendota Canal and can be viewed from county roads.

14.3.2.2.3 Southern San Joaquin Valley

In the southern portion of the San Joaquin Valley, the Kings, Kaweah, Tule, and Kern rivers are the principal water features along the eastern Sierra Nevada foothills. One or more reservoirs are located along each of these rivers. Riparian vegetation and oak woodlands occur along these river corridors. The western Coast Ranges foothills are characterized by distinct, folded foothills with grasslands and infrequent oak woodlands along small drainages. The Tehachapi Mountains rise abruptly along the southern boundary of the valley.

14.3.2.2.4 Wild and Scenic Rivers and Scenic Highways in the San Joaquin Valley

In the San Joaquin Valley within or near the Central Valley Region considered in this EIS, four rivers were designated to be part of the National Wild and Scenic Rivers System. Portions of the Tuolumne River from the source waters to Don Pedro Reservoir were designated through Public Law 98-425 as wild and scenic. Portions of the Merced River were designated through Public Laws 100-149 and 102-432 as wild and scenic, including the entire South Fork and the mainstem from the source waters to Lake McClure. Portions of the Kings River were designated as wild and scenic through Public Law 100-150, including the Middle Fork and South Fork from their respective sources to the confluences with the mainstem; and the mainstem from these confluences to an elevation of 1595 feet above mean sea level (upstream of the confluence with the North Fork and Pine Flat Lake). Portions of the Kern River were designated as wild and scenic through Public Law 100-174, including the North Fork from the source to the Tulare County/Kern County boundary; and the South Fork from the source to the Domeland Wilderness. Most of these reaches are located outside of the Central Valley Region; however, the flows from these reaches could influence the visual resources of downstream reaches in the Central Valley Region.

In the San Joaquin Valley of the Central Valley Region, there are five roadway sections designated as a State Scenic Highway and seven roadway sections that are eligible for this designation.

- San Joaquin County and Alameda County: Interstate 580 from Interstate 5 to State Route 205 is designated as a State Scenic Highway due to vistas of the Coast Ranges and Central Valley. Interstate 5 from the Stanislaus County boundary to Interstate 580 is designated as a State Scenic Highway due to vistas of agricultural lands and the Delta Mendota Canal and California Aqueduct (CalTrans 2014m, 2014n).
- Stanislaus County: Interstate 5 from the San Joaquin County boundary to the Merced County boundary is designated as a State Scenic Highway due to vistas of agricultural lands and the Delta Mendota Canal and California Aqueduct (CalTrans 2014o).
- Merced County: Interstate 5 from State Route 152 to the Stanislaus County boundary is designated as a State Scenic Highway due to vistas of agricultural lands and the Delta Mendota Canal and California Aqueduct (CalTrans 2014p). State Route 152 from Interstate 5 to the Santa Clara County boundary is designated as a State Scenic Highway due to vistas of agricultural lands and the San Luis Reservoir State Recreational Area.
- Fresno County: State Routes 168, 180, and 198 are eligible for State Scenic Highways designation (CalTrans 2014q).

- Tulare County: State Routes 190 and 198 are eligible for State Scenic Highways designation (CalTrans 2014s).
- Kern County: State Routes 14 and 58 are eligible for State Scenic Highways designation (CalTrans 2014t).

14.3.2.3 Delta and Suisun Marsh

Most of the Delta is used for agricultural purposes with major waterways and sloughs that connect the Sacramento, San Joaquin, Mokelumne, Cosumnes, and Calaveras rivers (CALFED 2000). Flood management and irrigation facilities include levees, impoundments, pumping plants, and control gate structures. Bodies of open water occur where historic levee failures were not repaired, including Franks Tract and Liberty Island. The Sacramento Deep Water Ship Channel is a larger water feature between levees that extends from the Sacramento River near Rio Vista to West Sacramento. Cities within the Delta include the southern portion of Sacramento, Isleton, West Sacramento, Rio Vista, Lathrop, western portions of Stockton and Manteca, Tracy, Brentwood, Oakley, Antioch, and Pittsburg. Small communities to serve the agriculture and recreation users include Freeport, Clarksburg, Hood, Courtland, Locke, Walnut Grove, Ryde, Thornton, Knightsen, and Collinsville. Vistas of the Delta can be seen from residences and agricultural areas in the Delta, open water areas used by recreationists, and from vehicles on roadways and railroads that cross the Delta. Waterfront industries are located along the rivers, especially along the San Joaquin River.

The Suisun Marsh is characterized by tidal and freshwater wetlands and riparian woodlands (Reclamation et al. 2010). The area is bounded by Interstate 80 and State Route 12 on the north; the Montezuma Hills and Sulphur Springs Mountains on the east and west, respectively; and on the south by the open waters of Suisun Bay, Grizzly Bay, and Honker Bay with adjoining wetlands, marshes, and riparian forests. The marsh is relatively flat and comprised primarily of tidal marsh and submerged lands. Upland areas serve as a backdrop with grasslands and nearby rolling foothills. Vistas of Suisun Marsh can be viewed from adjacent roadways railroads; roads and trails within the marsh; a few residences within the marsh; and open water that can be accessed by boats, kayaks, and canoes. Much of Suisun Marsh is managed wetlands and provides habitat for resident and migrating birds and waterfowl.

14.3.2.3.1 Scenic Highways in the Delta

In the Delta and Suisun Marsh portion of the Central Valley Region, there two roadway sections designated as a State Scenic Highway and two roadway sections that are eligible for this designation.

- Sacramento County: State Route 160 between the southern limits of the City of Sacramento to the Contra Costa County boundary is designated as a State Scenic Highway due to the views of historic Delta agriculture and small towns along the Sacramento River (CalTrans 2014u).

- Contra Costa County: State Route 160 from the Antioch Bridge to State Route 4 and State Route 4 continuing on towards Brentwood are eligible for State Scenic Highways designation (CalTrans 2014v).

14.3.3 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 San Francisco Bay Area Region ranges in topography from sea level to the East Bay and South Bay foothills that reach elevations of 3,500 feet and higher (CALFED 2000; WTA 2003; Reclamation 2005c). It offers a diverse physical and natural environment, and a wide range of visual resources. Typical views and landscapes include urban development, natural and altered open-space areas, major ridgelines, and scenic waterways. The terrain ranges from alluvial plains to gently sloping hills and wooded ravines. Striking views of iconic scenes are available throughout the area, of San Francisco Bay, the San Francisco skyline, Angel Island, Mount Tamalpais, Peninsula foothills, and the East Bay hills. Views to the east are dominated by Mount Diablo and adjacent Diablo Ridge and valleys. Views in the South Bay extend through the baylands that extend along the Contra Costa, San Mateo, Santa Clara, and Alameda counties shorelines; the river floodplains of the Guadalupe River and Coyote Creek in Santa Clara County; and towards the Santa Cruz Mountains (Santa Clara County 1994).

Urban and industrial areas are located throughout the San Francisco Bay Area Region, including along the San Francisco Bay shoreline. Smaller, localized scenic resources include wetlands, isolated hilltops, rock outcroppings, mature stands of trees, lakes, reservoirs, and other natural features. City parks and recreation areas, open-space areas adjacent to ravines, golf courses, and resource preserves provide visual opportunities in urban areas. The reservoirs that store CVP or SWP water or water from other surface water sources are human built reservoirs located in the foothills or at the edge of the foothills. The water can be viewed from roadways located at elevations higher than the reservoirs and by recreationists on the reservoirs. Agricultural areas that use CVP and SWP water are located within coastal valleys especially within the Livermore-Amador valleys of Alameda County, southern Santa Clara County, and northern San Benito County.

14.3.3.1 Scenic Highways in the San Francisco Bay Area Region

In the San Francisco Bay Area Region, there are four roadway sections designated as a State Scenic Highway and five roadway sections that are eligible for this designation.

- Contra Costa County: State Route 24 from the Alameda County boundary to Interstate 680, and Interstate 680 from State Route 24 to Interstate 580 at the Alameda County boundary are designated as State Scenic Highways due to the views of Mount Diablo and attractive residential and commercial areas (CalTrans 2014v).

- Alameda County: Interstate 580 between Interstate 80 and State Route 92 are designated as a State Scenic Highways (CalTrans 2014n). Portions of Interstate 680 from the Contra Costa County boundary to Mission Boulevard in Fremont and portions of State Route 84 are designated as State Scenic Highways due to vistas of wooded hillsides and valleys. Other portions of Interstate 580 are eligible for State Scenic Highways designation.
- Santa Clara County: Portions of State Routes 152 and 280 within the San Francisco Bay Area Region are eligible for State Scenic Highways designation (CalTrans 2014w).
- San Benito County: Portions of State Routes 156 and 25 within the San Francisco Bay Area Region are eligible for State Scenic Highways designation (CalTrans 2014x).

14.3.4 Central Coast and Southern California Regions

The Central Coast and Southern California Regions include portions of San Luis Obispo, Santa Barbara, Ventura, Los Angeles, Orange, San Diego, Riverside, and San Bernardino counties served by the SWP.

Areas along the Pacific Coast in San Luis Obispo, Santa Barbara, Ventura, portions of Los Angeles, portions of Orange, and San Diego counties are characterized by steep, craggy coastal mountains and coastal plains that can be viewed from the roadways, residences, and the Pacific Ocean. The visual resources include beaches, sand dunes, coastal bluffs, headlands, wetlands, estuaries, islands, hillsides, and canyons (Santa Barbara County 2009, SBCAG 2013). The foothills extend from the Pacific Ocean to more than 800 feet above mean sea level; and the mountains extend to more than 3,000 feet above mean sea level. The foothills are generally covered with mature trees and shrubs, including native oaks, deciduous trees, and eucalyptus. The coastal plains gradually slope towards the foothills with streams through the plains. Small to medium size communities occur along the coast and the coastal plains in San Luis Obispo, Santa Barbara, and Ventura counties and within portions of the coastline in Los Angeles, Orange and San Diego counties. Larger communities also are located along the coastline separated by large areas of undeveloped lands.

Inland from the Pacific Ocean, urban areas extend throughout large portions of the foothills and valleys of Los Angeles, Orange, San Diego, Riverside, and San Bernardino counties. Reduced abundance of natural features, vistas, and non-urban land uses may diminish the visual resources for many viewers (SCAG 2010). However, in many inland areas urban areas are separated by areas of undeveloped or agricultural lands, especially in Riverside and San Bernardino counties. Minimal development has occurred within the higher elevations of the Central Coast and Southern California regions, as described in Chapter 13, Land Use. Therefore, the mountainous areas (such as the San Gabriel, Santa Monica, Santa Ana, Santa Rosa, and San Jacinto mountains) provide dramatic viewsheds from the valleys (Los Angeles 2011, RCIP 2000, San Bernardino County 2007). The mountains also are characterized by deep canyons, rock outcroppings, and sparse vegetation. In the Coachella Valley portion of Riverside County, the visual resources are dominated by dramatic vistas of the Santa Rosa, San Jacinto, San Bernardino, Cottonwood, and Chocolate mountains with high desert craggy rock outcroppings and sparse vegetation. The Salton Sea in the southern Coachella Valley provides dramatic vistas from the shoreline and highways that extend around the open water.

The inland areas also include major surface water resources that provide open water vistas, including Twitchell Reservoir, Silverwood Lake, Diamond Valley Lake, Lake Perris, Lake Skinner, Vail Lake, and Lake Mathews; and smaller water supply reservoirs. Many of these reservoirs store CVP and SWP water and are human built reservoirs located in the foothills or at the edge of the foothills. The water can be viewed from highways located at elevations higher than the reservoirs and by recreationists on the reservoirs.

14.3.4.1 Wild and Scenic Rivers and Scenic Highways in the Central Coast and Southern California Regions

The wild and scenic rivers in the Central Coast and Southern California areas are not located within the study area of this EIS.

In the Central Coast and Southern California regions, there are seven roadway sections designated as State Scenic Highways and several roadway sections that are eligible for this designation.

- San Luis Obispo County: U.S. Highway 1 from the Monterey County boundary to the City of San Luis Obispo is designated as a State Scenic Highway and an All American Road due to dramatic vista along the mountains and rocky headlands of the Pacific Ocean coastline (CalTrans 2014y). Portions of State Route 41 and Interstate 101 are eligible for State Scenic Highways designation.
- Santa Barbara County: U.S. Highway 1 from Interstate 101 near Las Cruces to near Lompoc is designated as a State Scenic Highway due to dramatic vista along the mountains and rocky headlands of the Pacific Ocean coastline (CalTrans 2014z). Portions of Interstate 101 are eligible for State Scenic Highways designation.
- Ventura County: State Route 33 from the Santa Barbara County boundary to the north of the junction with State Route 150 is designated as a State Scenic Highway and a USFS Scenic Byway due to dramatic vista along the mountains between the Coast Ranges and the Central Valley with landscapes that range from pine forests to semi-desert vegetation (CalTrans 2014aa). Portions of Interstate 101 and State Routes 33 and 1 are eligible for State Scenic Highways designation.
- Los Angeles County: State Route 2 from near La Cañada-Flintridge to the San Bernardino County boundary is designated as a State Scenic Highway and a U.S. Forest Service Scenic Byway due to dramatic vista along the San Gabriel Mountains with vistas of the Mojave Desert and the Los Angeles Basin (CalTrans 2014ab). Portions of Interstate 101, 210, and 110 and State

Routes 1, 23, 27, 39, 118, and 126 are eligible for State Scenic Highways designation.

- Orange County: State Route 91 from State Route 55 to the City of Anaheim is designated as a State Scenic Highway due vistas of the Santa Ana River and urban development with intermittent riparian and chaparral vegetation (CalTrans 2014ac). State Routes 1, 57, and 74 and portions of State Route 91 are eligible for State Scenic Highways designation.
- San Diego County: State Route 75 from the City of Imperial Beach to Coronado is designated as a State Scenic Highway due to vistas of the Pacific Ocean, San Diego Harbor, and the Coronado Bridge (CalTrans 2014ad). State Route 125 between State Routes 94 and 8 is designated as a State Scenic Highway due to vistas of Mt. Helix and attractive residential and commercial areas. Interstate 5 and 8 and portions of State Routes 52, 76, and 93 within the Southern California Region are eligible for State Scenic Highways designation.
- Riverside County: State Route 243 from the City of Banning to State Route 74 is designated as a State Scenic Highway and a U.S. Forest Service Scenic Byway due to the vistas of the San Bernardino Mountains and valley (CalTrans 2014ae). Interstate 15 and State Routes 71, 74, 91, and 111 are eligible for State Scenic Highways designation.
- San Bernardino County: State Routes 2, 18, 38, 138, 173, 189, and 247 are eligible for State Scenic Highways designation (CalTrans 2014af).

14.4 Impact Analysis

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

14.4.1 Potential Mechanisms for Change and Analytical Methods

As described in Chapter 4, Approach to Environmental Analysis, the impact analysis considers changes in visual resources 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 change the vistas at reservoirs that store CVP and SWP water during dry and critical dry water years and at irrigated agricultural lands during dry and critical dry water years when the crops are idled.

14.4.1.1 Changes in Visual Resources at Reservoirs that Store CVP and SWP Water

Vistas at reservoirs that store CVP and SWP water provide a wide diversity of visual experiences related to the contrasts between the open water surface and surrounding foothills or mountains. By the end of September, the surface water elevations decline, and a bare "bathtub ring" appears in contrast to the open water and the upslope vegetation. Changes in CVP and SWP operations under the alternatives could change the extent of the "bathtub" ring over the long-term average condition and in dry and critical dry years as compared to the No Action Alternative and Second Basis of Comparison.

The CalSim II model output includes monthly reservoir elevations for CVP and SWP reservoirs in the Central Valley and Trinity Lake. The end-of-September reservoir elevations in dry and critical dry water years generally indicate low reservoir elevations. To assess changes in visual resources, changes in reservoir storage elevations for the end of September in dry and critical dry years were compared between alternatives and the No Action Alternative and Second Basis of Comparison.

Reservoirs in the San Francisco Bay Area, Central Coast, and Southern California regions store water from multiple water supplies including CVP and SWP water; however, these reservoirs are not included in the CalSim II model simulation. For the purposes of this EIS analysis, changes in surface water elevations in these reservoirs were assumed to be related to changes in CVP and SWP water deliveries to the areas located to the south of the Delta.

14.4.1.2 Changes in Vista at Irrigated Agricultural Lands

Agrarian vistas of irrigated row crops, orchards, and grazing lands intermixed within a landscape of grasslands, large water canals, isolated riparian corridors, and several small communities occur throughout the Central Valley, San Francisco Bay Area, Central Coast, and Southern California regions. Changes in CVP and SWP operations under the alternatives could change the extent of irrigated acreage and the associated vistas over the long-term average condition and in dry and critical dry years as compared to the No Action Alternative and Second Basis of Comparison. However, as described in Chapter 12, Agricultural Resources, the extents of irrigated acreage between Alternatives 1 through 5 are similar to irrigated acreage under the No Action Alternative and the Second Basis of Comparison. Therefore, changes in CVP and SWP operations would not change irrigated acreage and as a result they are not analyzed in this EIS.

14.4.1.3 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; pumping groundwater instead of using surface water (groundwater substitution); idle crops; or substitute crops that use 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 visual 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 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.

14.4.2 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. However, the changes to visual resources 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.

14.4.2.1 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

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 would also 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.

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 under the No Action Alternative and the Second Basis of Comparison. However, the CVP and SWP water deliveries would be less under the No Action Alternative as compared to the Second Basis of Comparison, as described in Chapter 5, Surface Water Resources and Water Supplies, which could result in more crop-idling.

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 visual resources, 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 would affect visual resources, 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
- Restoration of Battle Creek
- Implementation of Red Bluff Pumping Plant

14.4.3 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

14.4.3.1 No Action Alternative

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

14.4.3.1.1 Trinity River Region

Potential Changes in Visual Resources at Reservoirs that Store CVP and SWP Water

Changes in CVP water supplies and operations under the No Action Alternative as compared to the Second Basis of Comparison would result in similar end-of-September reservoir elevations (changes within 5 percent) and related visual resources at Trinity Lake in all water year types, as described in Chapter 5, Surface Water Resources and Water Supplies.

14.4.3.1.2 Central Valley Region

Potential Changes in Visual Resources at Reservoirs that Store CVP and SWP Water

Changes in CVP water supplies and operations under the No Action Alternative as compared to the Second Basis of Comparison would result in similar end-of-September reservoir elevations and related visual resources at Shasta Lake, Lake Oroville, Folsom Lake, and New Melones Reservoir in all water year types; and at San Luis Reservoir in above-normal, below-normal, and dry years, as described in Chapter 5, Surface Water Resources and Water Supplies. Changes in visual resources at San Luis Reservoir would be reduced in wet year and critical dry years because the end-of-September surface water elevations would be reduced by 6.2 percent in wet and critical dry years.

Effects Related to Cross Delta Water Transfers

Potential effects to visual 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 visual resources were identified as changes in reservoir surface water elevations, streams, irrigated acreage, and water elevations in canals that would convey transferred water. The analysis indicated that these potential impacts would not be substantial because the conditions with and without the water transfers would be similar.

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.

14.4.3.1.3 San Francisco Bay Area, Central Coast, and Southern California Regions

Potential Changes in Visual Resources at Reservoirs that Store CVP and SWP Water

Changes in visual resources at reservoirs that store CVP and SWP water supplies are assumed to be related to changes in water deliveries over long-term conditions for this EIS analysis. Monthly deliveries are not necessarily indicative of reservoir storage because all or a portion of the water deliveries could be directly conveyed to water users in any specific month. Therefore, annual deliveries are considered to be relatively proportional to the amount of water that could be stored over all water year types. In the San Francisco Bay Area Region, values for the CVP municipal and industrial water deliveries and the SWP south of the Delta water deliveries (without Article 21 deliveries) were considered; and SWP south of the Delta water deliveries (without Article 21 deliveries) were considered for the Central Coast and Southern California regions. Under the No Action Alternative as compared to the Second Basis of Comparison CVP water deliveries would be reduced by 10 percent and SWP water deliveries would be reduced by 18 percent. Therefore, for this EIS analysis, it is assumed that visual resources related to surface water elevations in reservoirs that store CVP and SWP water supplies would be reduced by 10 to 18 percent in the San Francisco Bay Area Region and 18 percent in the Central Coast and Southern California regions.

14.4.3.2 Alternative 1

Alternative 1 is identical to the Second Basis of Comparison. Alternative 1 is compared to the No Action Alternative and the Second Basis of Comparison. However, because visual resource conditions under Alternative 1 are identical to visual resource conditions under the Second Basis of Comparison; Alternative 1 is only compared to the No Action Alternative.

14.4.3.2.1 Alternative 1 Compared to the No Action Alternative

Trinity River Region

Potential Changes in Visual Resources at Reservoirs that Store CVP and SWP Water

Changes in CVP water supplies and operations under Alternative 1 as compared to the No Action Alternative would result in similar end-of-September reservoir elevations and related visual resources at Trinity Lake in all water year types, as described in Chapter 5, Surface Water Resources and Water Supplies.

Central Valley Region

Potential Changes in Visual Resources at Reservoirs that Store CVP and SWP Water

Changes in CVP water supplies and operations under Alternative 1 as compared to the No Action Alternative would result in similar end-of-September reservoir elevations and related visual resources at Shasta Lake, Lake Oroville, Folsom Lake, and New Melones Reservoir in all water year types; and at San Luis Reservoir in above-normal, below-normal, and dry years, as described in Chapter 5, Surface Water Resources and Water Supplies. Changes in visual resources at San Luis Reservoir would be reduced in wet year and critical dry years because the end-of-September surface water elevations would be increased by 6.6 percent in wet and critical dry years.

Effects Related to Cross Delta Water Transfers

Potential effects to visual 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 impacts on visual resources 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.

San Francisco Bay Area, Central Coast, and Southern California Regions

Potential Changes in Visual Resources at Reservoirs that Store CVP and SWP Water

Changes in visual resources at reservoirs that store CVP and SWP water supplies are assumed to be related to changes in water deliveries over long-term conditions for this EIS analysis, as described above under the No Action Alternative as compared to the Second Basis of Comparison. Therefore, under Alternative 1 as compared to the No Action Alternative, visual resources related to surface water elevations in reservoirs that store CVP and SWP water supplies would be increased by 11 to 21 percent in the San Francisco Bay Area Region and 21 percent in the Central Coast and Southern California regions.

14.4.3.2.2 Alternative 1 Compared to the Second Basis of Comparison

Alternative 1 is identical to the Second Basis of Comparison.

14.4.3.3 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.

14.4.3.3.1 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 visual resources conditions under Alternatives 2 as compared to the Second Basis of Comparison would be the same as the impacts described in Section 14.4.3.1, No Action Alternative.

14.4.3.4 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 with modified Old and Middle River flow criteria and New Melones Reservoir operations. As described in Chapter 4, Approach to Environmental Analysis, Alternative 3 is compared to the No Action Alternative and the Second Basis of Comparison.

14.4.3.4.1 Alternative 3 Compared to the No Action Alternative

Trinity River Region

Potential Changes in Visual Resources at Reservoirs that Store CVP and SWP Water

Changes in CVP water supplies and operations under Alternative 3 as compared to the No Action Alternative would result in similar end-of-September reservoir elevations and related visual resources at Trinity Lake in all water year types, as described in Chapter 5, Surface Water Resources and Water Supplies.

Central Valley Region

Potential Changes in Visual Resources at Reservoirs that Store CVP and SWP Water

Changes in CVP water supplies and operations under Alternative 3 as compared to the No Action Alternative would result in similar end-of-September reservoir elevations and related visual resources at Shasta Lake, Lake Oroville, Folsom Lake, and New Melones Reservoir in all water year types; and at San Luis Reservoir in below-normal, dry, and critical dry years, as described in Chapter 5, Surface Water Resources and Water Supplies. Changes in visual resources at San Luis Reservoir would be reduced in wet year and critical dry years because the end-of-September surface water elevations would be increased by 7.9 percent in wet years and 5.7 percent in above-normal years.

Effects Related to Cross Delta Water Transfers

Potential effects to visual 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 impacts on visual resources 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.

San Francisco Bay Area, Central Coast, and Southern California Regions

Potential Changes in Visual Resources at Reservoirs that Store CVP and SWP Water

Changes in visual resources at reservoirs that store CVP and SWP water supplies are assumed to be related to changes in water deliveries over long-term conditions for this EIS analysis, as described above under the No Action Alternative as compared to the Second Basis of Comparison. Therefore, under Alternative 3 as compared to the No Action Alternative, visual resources related to surface water elevations in reservoirs that store CVP and SWP water supplies would be increased by 9 to 17 percent in the San Francisco Bay Area Region and 17 percent in the Central Coast and Southern California regions.

14.4.3.4.2 Alternative 3 Compared to the Second Basis of Comparison

Trinity River Region

Potential Changes in Visual Resources at Reservoirs that Store CVP and SWP Water

Changes in CVP water supplies and operations under Alternative 3 as compared to the Second Basis of Comparison would result in similar end-of-September reservoir elevations and related visual resources at Trinity Lake in all water year types, as described in Chapter 5, Surface Water Resources and Water Supplies.

Central Valley Region

Potential Changes in Visual Resources at Reservoirs that Store CVP and SWP Water

Changes in CVP water supplies and operations under Alternative 3 as compared to the Second Basis of Comparison would result in similar end-of-September reservoir elevations and related visual resources at Shasta Lake, Lake Oroville, Folsom Lake, New Melones Reservoir, and San Luis Reservoir in all water year types, as described in Chapter 5, Surface Water Resources and Water Supplies.

Effects Related to Cross Delta Water Transfers

Potential effects to visual 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 impacts on visual resources 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.

San Francisco Bay Area, Central Coast, and Southern California Regions

Potential Changes in Visual Resources at Reservoirs that Store CVP and SWP Water

Changes in visual resources at reservoirs that store CVP and SWP water supplies are assumed to be related to changes in water deliveries over long-term conditions for this EIS analysis, as described above under the No Action Alternative as compared to the Second Basis of Comparison. Therefore, under Alternative 3 as compared to the Second Basis of Comparison, visual resources related to surface water elevations in reservoirs that store CVP and SWP water supplies would be similar (changes within 5 percent).

14.4.3.5 Alternative 4

The visual resources conditions 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.

14.4.3.5.1 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 visual resources conditions under Alternative 4 as compared to the No Action Alternative would be the same as the impacts described in Section 14.4.3.2.1, Alternative 1 Compared to the No Action Alternative.

14.4.3.6 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 Rivers (OMR) 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.

14.4.3.6.1 Alternative 5 Compared to the No Action Alternative

Trinity River Region

Potential Changes in Visual Resources at Reservoirs that Store CVP and SWP Water

Changes in CVP water supplies and operations under Alternative 5 as compared to the No Action Alternative would result in similar end-of-September reservoir elevations and related visual resources at Trinity Lake in all water year types, as described in Chapter 5, Surface Water Resources and Water Supplies.

Central Valley Region

Potential Changes in Visual Resources at Reservoirs that Store CVP and SWP Water

Changes in CVP water supplies and operations under Alternative 5 as compared to the No Action Alternative would result in similar end-of-September reservoir elevations and related visual resources at Shasta Lake, Lake Oroville, Folsom Lake, New Melones Reservoir, and San Luis Reservoir in all water year types, as described in Chapter 5, Surface Water Resources and Water Supplies.

Effects Related to Cross Delta Water Transfers

Potential effects to visual 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 impacts on visual resources 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.

San Francisco Bay Area, Central Coast, and Southern California Region

Potential Changes in Visual Resources at Reservoirs that Store CVP and SWP Water

Changes in visual resources at reservoirs that store CVP and SWP water supplies are assumed to be related to changes in water deliveries over long-term conditions for this EIS analysis, as described above under the No Action Alternative as compared to the Second Basis of Comparison. Therefore, under Alternative 5 as compared to the No Action Alternative, visual resources would be similar.

14.4.3.6.2 Alternative 5 Compared to the Second Basis of Comparison

Trinity River Region

Potential Changes in Visual Resources at Reservoirs that Store CVP and SWP Water

Changes in CVP water supplies and operations under Alternative 5 as compared to the Second Basis of Comparison would result in similar end-of-September reservoir elevations and related visual resources at Trinity Lake in all water year types, as described in Chapter 5, Surface Water Resources and Water Supplies.

Central Valley Region

Potential Changes in Visual Resources at Reservoirs that Store CVP and SWP Water

Changes in CVP water supplies and operations under Alternative 5 as compared to the Second Basis of Comparison would result in similar end-of-September reservoir elevations and related visual resources at Shasta Lake, Lake Oroville, Folsom Lake, and New Melones Reservoir in all water year types; and at San Luis Reservoir in wet, above-normal, and below-normal years, as described in Chapter 5, Surface Water Resources and Water Supplies. Changes in visual resources at San Luis Reservoir would be reduced in dry year and critical dry years because the end-of-September surface water elevations would be decreased by 6.2 percent in dry years and 8.5 percent in critical dry years.

Effects Related to Cross Delta Water Transfers

Potential effects to visual 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 impacts on visual resources 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.

San Francisco Bay Area, Central Coast, and Southern California Regions

Potential Changes in Visual Resources at Reservoirs that Store CVP and SWP Water

Changes in visual resources at reservoirs that store CVP and SWP water supplies are assumed to be related to changes in water deliveries over long-term conditions for this EIS analysis, as described above under the No Action Alternative as compared to the Second Basis of Comparison. Therefore, under Alternative 5 as compared to the Second Basis of Comparison, visual resources related to surface water elevations in reservoirs that store CVP and SWP water supplies would be reduced by 10 to 18 percent in the San Francisco Bay Area Region and 18 percent in the Central Coast and Southern California regions.

14.4.3.7 Summary of Impact Assessment

The results of the impact assessment of implementation of Alternatives 1 through 5 as compared to the No Action Alternative and the Second Basis of Comparison are presented in Tables 14.1 and 14.2.

Table 14.1 Comparison of Alternatives 1 through 5 to No Action Alternative

Alternative	Potential Change	Consideration for Mitigation Measures
Alternative 1	Visual resources would be similar at Trinity Lake, Shasta Lake, Lake Oroville, Folsom Lake, and New Melones Reservoir in all water year types; and at San Luis Reservoir in above-normal, below-normal, and dry years. Visual resources would be increased by 6 percent in wet and critical dry years at San Luis Reservoir, by 11 to 21 percent in the San Francisco Bay Area Region, and by 21 percent in the Central Coast and Southern California regions.	None needed.
Alternative 2	No effects on visual resources.	None needed.
Alternative 3	Visual resources would be similar at Trinity Lake, Shasta Lake, Lake Oroville, Folsom Lake, and New Melones Reservoir in all water year types; and at San Luis Reservoir in above-normal, below-normal, and dry years. Visual resources would be increased by 8 percent in wet years and 6 percent in above-normal years at San Luis Reservoir, by 9 to 17 percent in the San Francisco Bay Area Region, and by 17 percent in the Central Coast and Southern California regions.	None needed.
Alternative 4	Same effects as described for Alternative 1 compared to the No Action Alternative.	None needed.
Alternative 5	Visual resources would be similar at Trinity Lake, Shasta Lake, Lake Oroville, Folsom Lake, San Luis Reservoir, and other reservoirs that store CVP and SWP water in the San Francisco Bay Area, Central Coast, and Southern California regions.	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 14.2 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	Visual resources would be similar at Trinity Lake, Shasta Lake, Lake Oroville, Folsom Lake, and New Melones Reservoir in all water year types; and at San Luis Reservoir in above-normal, below-normal, and dry years. Visual resources would be reduced by 6 percent in wet and critical dry years at San Luis Reservoir, by 10 to 18 percent in the San Francisco Bay Area Region, and by 18 percent in the Central Coast and Southern California regions.	Not considered for this comparison.
Alternative 1	No effects on visual resources.	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	Visual resources would be similar at Trinity Lake, Shasta Lake, Lake Oroville, Folsom Lake, San Luis Reservoir, and other reservoirs that store CVP and SWP water in the San Francisco Bay Area, Central Coast, and Southern California regions.	Not considered for this comparison.
Alternative 4	No effects on visual resources.	Not considered for this comparison.
Alternative 5	Visual resources would be similar at Trinity Lake, Shasta Lake, Lake Oroville, Folsom Lake, and New Melones Reservoir in all water year types; and at San Luis Reservoir in above-normal, below-normal, and dry years. Visual resources would be reduced by 6 percent in dry years and 9 percent in critical dry years at San Luis Reservoir, by 10 to 18 percent in the San Francisco Bay Area Region, and by 18 percent in the Central Coast and Southern California regions.	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."

14.4.3.8 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.

Changes in CVP and SWP operations under Alternatives 1 through 5, as compared to the No Action Alternative, would not result in changes in visual resources. Therefore, there would be no adverse impacts to visual resources and no mitigation measures are required.

14.4.3.9 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 Visual Resources are summarized in Table 14.3.

Table 14.3 Summary of Cumulative Effects on Visual Resources with Implementation 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: 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 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): - 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 - General plans for 2030. - Trinity River Restoration Program. - Central Valley Project Improvement Act programs - Folsom Dam Water Control Manual Update - FERC Relicensing for the Middle Fork of the American River Project - Lower Mokelumne River Spawning Habitat Improvement Project	<u>These effects would be the same under all alternatives.</u> 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 end of September storage in CVP and SWP reservoirs compared to past conditions, and to reduce CVP and SWP water supply reliability which could result in less irrigated lands compared to past conditions. General plans would be completed for projected conditions by 2030, as described in Chapter 13, Land Use. Restoration plans for the ongoing programs would be completed which would change visual resources of the restored lands.

Scenarios	Actions	Cumulative Effects of Actions
	- Dutch Slough Tidal Marsh Restoration - Suisun Marsh Habitat Management, Preservation, and Restoration Plan Implementation - Tidal Wetland Restoration: Yolo Ranch, Northern Liberty Island Fish Restoration Project, Prospect Island Restoration Project, and Calhoun Cut/Lindsey Slough Tidal Habitat Restoration Project - San Joaquin River Restoration Program - Future water supply projects, including water recycling, desalination, groundwater banks and wellfields, and conveyance facilities (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): - Bay-Delta Water Quality Control Plan Update - FERC Relicensing Projects - Bay Delta Conservation Plan (including the California WaterFix alternative) - Shasta Lake Water Resources, North-of-the-Delta Offstream Storage, Los Vaqueros Reservoir Expansion Phase 2, and Upper San Joaquin River Basin Storage Investigations - El Dorado Water and Power Authority Supplemental Water Rights Project - Sacramento River Water Reliability Project - Semitropic Water Storage District Delta Wetlands - North Bay Aqueduct Alternative Intake - San Luis Reservoir Low Point Improvement Project - 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 under all alternatives.</u> 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. 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 and associated extent of irrigated lands.

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 BO	Climate change and sea level rise, FERC relicensing projects, and some future projects to improve water quality and/or habitat are anticipated to reduce end of September CVP and SWP reservoir storage as compared to past conditions. Community development would occur in accordance with general plan projections for 2030. Restoration plans for the ongoing programs would be completed. Future water supply projects are anticipated to both increase water supply reliability due to reduced surface water supplies and to accommodate planned growth in the general plans.
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 actions would result in similar changes as under the No Action Alternative with the added 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 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 actions would result in similar changes 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) Slight increase in positive Old and Middle River flows in the winter and spring months	Implementation of Alternative 3 with future reasonably foreseeable actions would result in similar changes as under the No Action Alternative with the added actions.
Alternative 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 Alternative 4 with future reasonably foreseeable actions would result in similar changes as under the No Action Alternative with the added actions.
Alternative 5 with Associated Cumulative Effects Actions in Year 20530	Full implementation of the 2008 USFWS BO and 2009 NMFS BO Positive Old and Middle River flows and increased Delta outflow in spring months	Implementation of Alternative 5 with future reasonably foreseeable actions would result in similar changes as under the No Action Alternative with added actions.

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