RECLAMATION

Managing Water in the West

Long-Term Plan to Protect Adult Salmon in the Lower Klamath River

Humboldt County, California

Draft Environmental Impact Statement

U.S. Department of the Interior
Bureau of Reclamation

October 2016

Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

Draft Environmental Impact Statement
Long-Term Plan to Protect Adult Salmon in the Lower Klamath River

United States Department of the Interior
Bureau of Reclamation, Northern California Area Office
16349 Shasta Dam Blvd.
Shasta Lake, CA 96019

This Draft Environmental Impact Statement (EIS) for the Long-Term Plan to Protect Adult Salmon in the Lower Klamath River has been prepared by the U.S. Department of the Interior, Bureau of Reclamation, Northern California Area Office, consistent with requirements of the National Environmental Policy Act (NEPA). Cooperating agencies pursuant to NEPA are the Hoopa Valley Tribe, Karuk Tribe, Klamath Tribes, Yurok Tribe, U.S. Fish and Wildlife Service, National Marine Fisheries Service, Bureau of Indian Affairs, California Department of Fish and Wildlife, Humboldt County, and the San Luis & Delta-Mendota Water Authority.

This Draft EIS describes the potential environmental effects of the No Action Alternative and the action alternatives to augment flows in the lower Klamath River to reduce the likelihood, and potentially reduce the severity, of any Ichthyophthirius multifiliis (Ich) epizootic event that could lead to an associated fish die-off in future years.

In accordance with NEPA review requirements, this Draft EIS will be circulated for public and agency review and comment for a 45-day period following the date when the U.S. Environmental Protection Agency publishes the notice of availability in the Federal Register. Written comments from the public, reviewing agencies, and stakeholders will be accepted throughout the public comment period, which ends on December 5, 2016. Comments can be emailed to BOR-SLO-sha-ltpeis-public-comments@usbr.gov or mailed to Julia Long, Bureau of Reclamation, Northern California Area Office, 16349 Shasta Dam Blvd., Shasta Lake, CA 96019. A public hearing will be held to solicit and receive public input on the Draft EIS. Comments received during the public comment period will be considered in the development of the Final EIS.

For further information, please contact Julia Long, Project Manager, at the address above, via telephone at (530) 276-2044, or by e-mail at jlong@usbr.gov.

Executive Summary

In conformance with the National Environmental Policy Act (NEPA) of 1969, Council on Environmental Quality (CEQ) regulations (40 CFR 1500-1508), and Department of Interior (DOI) Regulations (43 CFR Part 46), the U.S. Department of the Interior, Bureau of Reclamation (Reclamation), as the lead agency, prepared this Environmental Impact Statement (EIS) to evaluate and disclose potential environmental impacts associated with implementing the Long-Term Plan to Protect Adult Salmon in the Lower Klamath River (LTP). The proposed action is to increase lower Klamath River flows to reduce the likelihood, and potentially reduce the severity, of any fish die-off in future years due to crowded holding conditions for pre-spawn adults, warm-water temperatures, and the presence of disease pathogens—which are likely the major factors contributing to adult mortalities.

Background and History

In September 2002, an unforeseen and unprecedented fish die-off occurred during a two-week period in the lower Klamath River. A subsequent U.S. Fish and Wildlife Service (USFWS) report indicated that of the approximately 34,000 anadromous salmonids estimated to have perished during this event, nearly all (98.4 percent) were adult salmonids. Of this total, 97 percent were fall-run Chinook Salmon, 1.8 percent were steelhead, and 1 percent were Coho Salmon. The two fish disease pathogens leading to the die-off were identified as *Ichthyophthirius multifiliis* (Ich) and *Flavobacter columnare* (Columnaris). High fish densities—due to the relatively large run size (approximately 170,000 adult Chinook Salmon), low flows, and relatively high water temperatures—were identified as causative factors for the rapid spread of disease. Although a larger number of Klamath River fall-run Chinook Salmon died, a greater proportion of the Trinity River run was lost because the die-off occurred during the peak migration of the Trinity River fish. Since 2002, Reclamation has been working with stakeholders to protect fall-run Chinook Salmon returning to the Klamath and Trinity Rivers.

Since the large-scale die-off of 2002, heightened concern over a disease outbreak and related large-scale adult salmon mortalities re-emerged, due to forecasted and observed fisheries and hydrologic conditions during 2003, 2004, 2012, 2013, 2014, 2015, and 2016. In response to this concern, Reclamation provided augmentation flows during these years to improve fishery conditions in the lower Klamath River. As shown in Figure ES-1, the volume of the augmentation flows ranged from 17.5 thousand acre-feet (TAF) in 2013 to 64 TAF in 2014, with an average volume of approximately 40 TAF. No large-scale adult salmon mortalities have occurred since 2002. During this time, Reclamation collaborated with tribes, regulatory agencies, and other basin partners, and consulted with water and power users, to develop and refine monitoring and flow augmentation criteria.

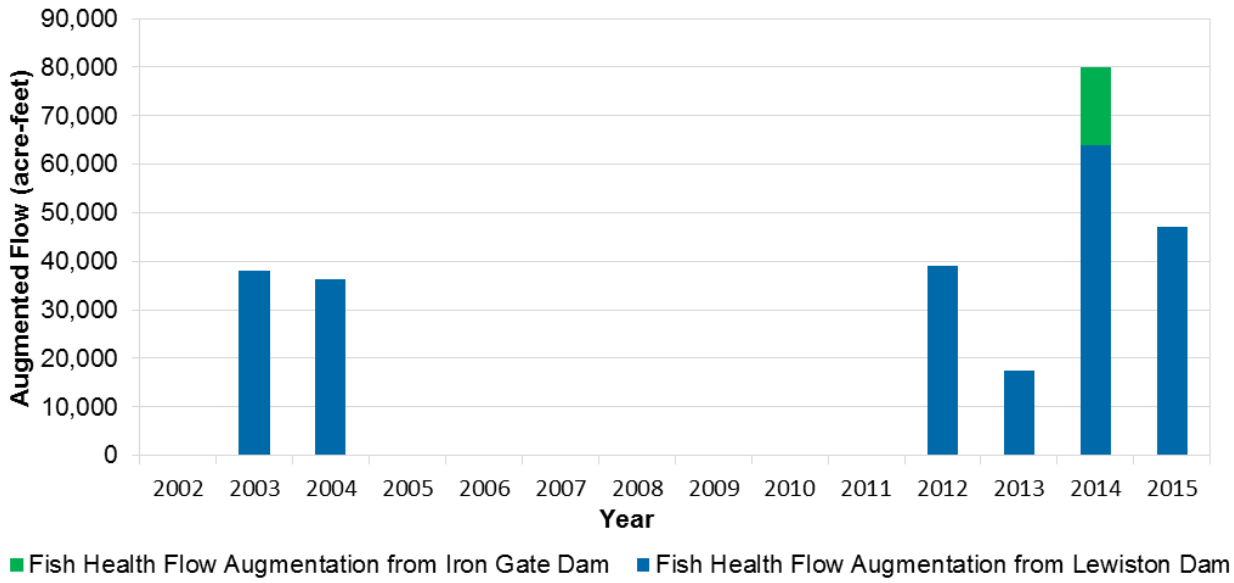


Figure ES-1. Flow Augmentation Releases Made by Reclamation and PacifiCorp from 2003 to 2015 to Reduce the Prevalence of Fish Disease in the Lower Klamath River

Development of the Draft Long-Term Plan for Protecting Late-Summer Adult Salmon in the Lower Klamath River

In response to the need for augmentation flows in the past several years, the indication that such flows may be needed in future years, and competing environmental and water supply demands for Trinity River Division (TRD) of the Central Valley Project (CVP) water supplies, Reclamation started developing the *Draft Long-Term Plan for Protecting Late-Summer Adult Salmon in the Lower Klamath River* (Draft LTP) in 2013. An initial Draft LTP was provided to key stakeholders on December 31, 2014. Reclamation received comments from tribes, fisheries agencies, water users, power users, and other stakeholders. The Draft LTP was revised and released to the public on April 17, 2015. Reclamation continues to refine the flow augmentation actions, processes, and monitoring that were identified in the Draft LTP, as outlined in this EIS.

Scoping Process

The EIS scoping process was initiated on July 14, 2015, with publication of the Notice of Intent (NOI) in the Federal Register. To date, Reclamation has held scoping, cooperating agency, and tribal information meetings, to inform the public and interested stakeholders about the project, and to solicit comments and input on this EIS. Comments received during the scoping process have covered a range of topics, including potential impacts to address in the EIS and suggested alternatives, many of which have come from cooperating agencies. The cooperating agencies for this EIS are the Hoopa Valley Tribe, Karuk Tribe, Klamath Tribes, Yurok Tribe, USFWS, National Marine Fisheries Service (NMFS), Bureau of Indian Affairs (BIA), California Department of Fish and Wildlife (CDFW), Humboldt County, and the San Luis & Delta-Mendota Water Authority.

Alternatives

Alternatives were developed to meet the Purpose and Need for the project, which is to reduce the likelihood, and potentially reduce the severity, of any Ich epizootic event that could lead to an associated fish die-off in future years. The need is based on the past extensive fish die-off in 2002.

Alternatives Development Process

During the alternatives development process, a number of alternatives or measures were identified and evaluated, in consideration of input received during the public scoping process. In determining which alternatives would be carried forward, Reclamation considered how effectively the alternatives would meet the Purpose and Need, including Reclamation's ability to implement the alternatives as necessary (potentially as early as August 2017). Specifically, Reclamation considered the alternatives' ability to address one or more of the significant contributing factors to Ich epizootic events. To be viable, alternatives need to have the capability of meaningfully and substantially reducing the likelihood—and potentially reducing the severity—of any Ich epizootic event that could lead to an associated fish die-off.

No Action Alternative

The No Action Alternative represents future conditions without implementation of the proposed action, and the resulting environmental effects from taking no action. Under the No Action Alternative, Reclamation would not implement flow augmentation actions to supplement flows in the lower Klamath River.

The No Action Alternative assumes continued implementation of existing projects, plans, ecosystem restoration projects (e.g., Trinity River Restoration Program), land or resource management plans, water supply management and wastewater facilities, flood management facilities, and recreational facilities. The No Action Alternative assumes future conditions such as climate change and sea-level rise, the development of lands in accordance with general plans in areas served by CVP water supplies, and continued operation of the CVP to the year 2030. The No Action Alternative also includes PacifiCorp operating their Klamath Hydroelectric Project under the current annual license, with the dams remaining in place.

Proposed Action (Alternative 1)

The Proposed Action (Alternative 1) includes supplemental flows from Lewiston Dam to prevent a disease outbreak in the lower Klamath River in years when the river's flow is projected to be less than 2,800 cubic feet per second (cfs). The water for these supplemental flows would come from water stored in Trinity Reservoir, to support "appropriate measures for the preservation and propagation of fish and wildlife" (Proviso 1) with releases of "not less than 50,000 acre-feet" for Humboldt County and downstream water users (Proviso 2), as provided in the 1955 Trinity River Division Act.

Flow Augmentation Components

The Proposed Action is comprised of three different flow augmentation components to be implemented as needed in a phased approach, based on environmental (e.g., flow) and biological conditions. The three components include: (1) a preventive base flow release that intends to increase the base flow of the lower Klamath River to 2,800 cfs, from mid-August to late

September, to improve environmental conditions; (2) a one-day 5,000 cfs preventive pulse flow to be used as a secondary measure, to alleviate continued poor environmental conditions and to respond to signs of Ich infection in the lower Klamath River; and (3) a five-day, 5,000 cfs emergency pulse flow, to be used on an emergency basis as a tertiary treatment, to avoid a significant die-off of adult salmon when the first two components of the Proposed Action are not successful at meeting their intended objectives. Reclamation would implement these flow augmentation components in coordination with Federal, State, and tribal resource specialists, including fisheries biologists and pathologists (i.e., LTP Technical Team).

Preventive Base Flow Augmentation Initiate preventive base flow augmentation from Lewiston Dam when one or more of the following conditions occur:

- Flow in the lower Klamath River is projected to be less than 2,800 cfs at the Klamath, California gage in August and September.
- Ich infection of adult salmon or steelhead is identified in July and early August, suggesting a low-level infection is present that could worsen with poor environmental conditions.
- Thermal regime of the lower Klamath River is inhibitory to the upstream migration of infected adult salmon.
- High densities of Chinook Salmon and steelhead are holding in the lower Klamath River.

In coordination with the LTP Technical Team, Reclamation will initiate preventive base flow augmentation releases by August 22 to meet the target flow (2,800 cfs) in the lower Klamath River, if the fish harvest metric above is not met. Reclamation will continue flow augmentation to target a flow of 2,800 cfs in the lower Klamath River, as measured at the Klamath, California gage through September 21. The LTP Technical Team would continue to implement fish pathology monitoring to determine the potential need for the secondary flow augmentation action (i.e., preventive pulse flow).

Preventive Pulse Flow During the preventive base flow period, a preventive pulse flow—targeting a rate of 5,000 cfs for one 24-hour period at the Klamath, California gage—would occur when the peak fall-run migration (typically the first or second week of September) is identified in the lower Klamath River, as indicated by fish density. This enhanced flow level, based on 2015 experience, intends to use a small volume of water to provide a change to the environmental conditions of the lower Klamath River, further reducing the Ich infection risk. Conditional release of this pulse flow requires confirmed low-level infections of Ich (less than 30 Ich per gill arch) on three fall-run adult salmon (of a maximum sample size of 60 fish), captured in the lower Klamath River in one day during typical peak migration, subject to LTP Technical Team review.

Emergency Pulse Flow Augmentation Initiate an emergency flow release to target a flow of 5,000 cfs in the lower Klamath River, for up to five days in August or September, if these emergency conditions exist as identified by USFWS and NMFS:

- Diagnosis of severe Ich infection of gills (30 or more parasites on a gill arch) in 5 percent or greater of a desired sample of 60 adult salmonids confirmed by the USFWS' California/Nevada (CA/NV) Fish Health Center, or

- Observed mortality of greater than 50 dead adult salmonids in a 20 kilometer reach in 24 hours, coupled with the confirmed presence of Ich by the USFWS CA/NV Fish Health Center.

Annual Implementation Process

The annual implementation process, beginning in late March, outlines a month-by-month process to determine: whether augmentation flows are required in a given year; which water source(s) would be used for augmentation flows; and, to finalize and implement augmentation flows. Table ES-1 presents the process by month that Reclamation would follow.

Table ES-1. Annual Implementation Schedule for Alternatives 1 and 2

Timeframe	Actions
March through May	1. Reclamation obtains Klamath Basin accretion forecasts from NOAA California Nevada River Forecast Center 2. Reclamation develops projections for lower Klamath River flows through September, based on: NOAA accretion forecast, 2013 USFWS and NMFS Klamath Project Biological Opinion release requirements from Iron Gate Dam; tribal boat dance flows (even years in the Klamath River, and odd years in the Trinity River); and the Trinity River ROD flows from Lewiston Dam 3. Reclamation assesses environmental conditions and the applicability of augmentation criteria in collaboration with tribes and resource agencies 4. Reclamation assesses hydrologic conditions (current and projected) and water supply allocations in the CVP 5. Reclamation coordinates with the USFWS, CDFW and NMFS
May through July	1. Reclamation collaborates with tribes, CVP water and power users, regulatory agencies, and other key stakeholders for additional input 2. The LTP Technical Team continues to assess environmental conditions and the need for augmentation flows[1] 3. Reclamation refines the augmentation flow regime, if applicable 4. Reclamation coordinates with Humboldt County on potential use of their Contractual Right for preventive and emergency flow actions
August through September	1. Preventive flow augmentation is implemented, if needed 2. The LTP Technical Team conducts monitoring, evaluates data and conditions, and determines the need for supplemental actions; including preventive pulse flow and emergency pulse flow augmentation[1]
October through December	1. The LTP Technical Team convenes to review and document outcomes from the year's activities

Notes:

[1] The LTP Technical Team would consist of Federal, State, and tribal resource specialists, including fisheries biologists or pathologists.

Key:

CDFW = California Department of Fish and Wildlife
CVP = Central Valley Project
NMFS = National Marine Fisheries Service
NOAA = National Oceanic and Atmospheric Administration
Reclamation = U.S. Department of the Interior, Bureau of Reclamation
ROD = Record of Decision
LTP = Long-Term Plan to Protect Adult Salmon in the Lower Klamath River
USFWS= U.S. Fish and Wildlife Service

Monitoring and Research

Monitoring and research efforts will include both essential monitoring actions (e.g., monitoring required to measure the flow augmentation component triggers, such as Ich infestation level), as well as additional monitoring and research actions, to inform potential refinement of flow augmentation trigger criteria.

Essential Monitoring Actions The following required essential monitoring actions evaluate if the specific criteria have been triggered for the three flow augmentation components. Essential monitoring actions would be performed annually, including:

- **Flow and Water Temperature** – Real-time flow and water temperature data would be obtained from existing U.S. Geological Survey stream gages along the Klamath and Trinity Rivers.

- **Fish Density Including Estuary Counts** – The Yurok Tribe would collect harvest and catch effort data for the estuary. In addition, other methods for determining fish densities will be developed through research and monitoring actions.

- **Fish Health Monitoring (Ich)** – Monitoring and assessment of salmon and steelhead for the presence of Ich would be conducted along the lower Klamath River during late-summer and fall months (July through October).

Potential Additional Monitoring and Research Actions and Flow Component Trigger Criteria Refinement As part of the Proposed Action, additional monitoring and research actions would be conducted—furthering scientific understanding of causative factors of Ich infection and outbreak in the lower Klamath River. Based on the concept of adaptive management, and utilizing additional scientific information on causative factors, Reclamation may refine trigger criteria for the three flow components (i.e., preventive base flow augmentation, preventive pulse flows, and emergency pulse flow augmentation) to further reduce the likelihood—and potentially the severity—of any Ich epizootic event. The process for potential refinement of flow component trigger criteria will be based on adaptive management principles, as follows:

- Develop hypotheses and conceptual models to identify potential causative factors (e.g., identification of relationships between salmon and environmental conditions—including pathogens—between ecological processes and potential management actions).

- Develop and refine performance measures related to reducing the likelihood of Ich epizootic events and associated fish die-offs.

- Collect and evaluate relevant data and other information pertaining to physical and biotic components of the Klamath River system, salmon performance, pathogen presence, and Ich infestation.

- Propose modifications to flow augmentation trigger criteria that would decrease the likelihood—and potentially the severity—of Ich epizootic outbreaks.

- Recommend implementation of additional monitoring and research programs to examine how selected management actions meet performance measures.

The purpose of adaptive management is to allow for mid-course corrections that can be taken to better manage flow as new information becomes available. For example, the flow target of 2,800 cfs could be modified through an adaptive management approach, as could the frequency of flow augmentation actions. While it is likely that adjustments in flow may lead to using less water as causative factors become better understood, it is also possible that additional flow may be necessary. Reclamation would prepare supplemental environmental documentation, as necessary, as changes to the flow augmentation actions are contemplated based on new information gained through adaptive management.

Alternative 2 – Trinity River ROD Flow Rescheduling Alternative

The Trinity River Record of Decision (ROD) provides for annual instream flows below Lewiston Dam according to the recommendations provided in the Trinity River Mainstem Fishery Restoration Final EIS/Environmental Impact Report (EIR). The Trinity River ROD Flow Rescheduling Alternative (Alternative 2) includes supplemental flows from Lewiston Dam, to prevent a disease outbreak in the lower Klamath River, in years when the river's flow is projected to be less than 2,800 cfs. Supplemental flows would come sequentially from water stored in Trinity Reservoir, primarily through modifying the pattern of releases (i.e., rescheduling) for Trinity River ROD flows. If rescheduling of Trinity River ROD flows is insufficient to meet flow augmentation requirements, water would be released pursuant to authorities provided in the 1955 Trinity River Division Act, including Provisos 1 and 2. The supplemental flows would involve the same three components described for the Proposed Action (Alternative 1), including preventive base flow augmentation, preventive pulse flow, and emergency pulse flow augmentation.

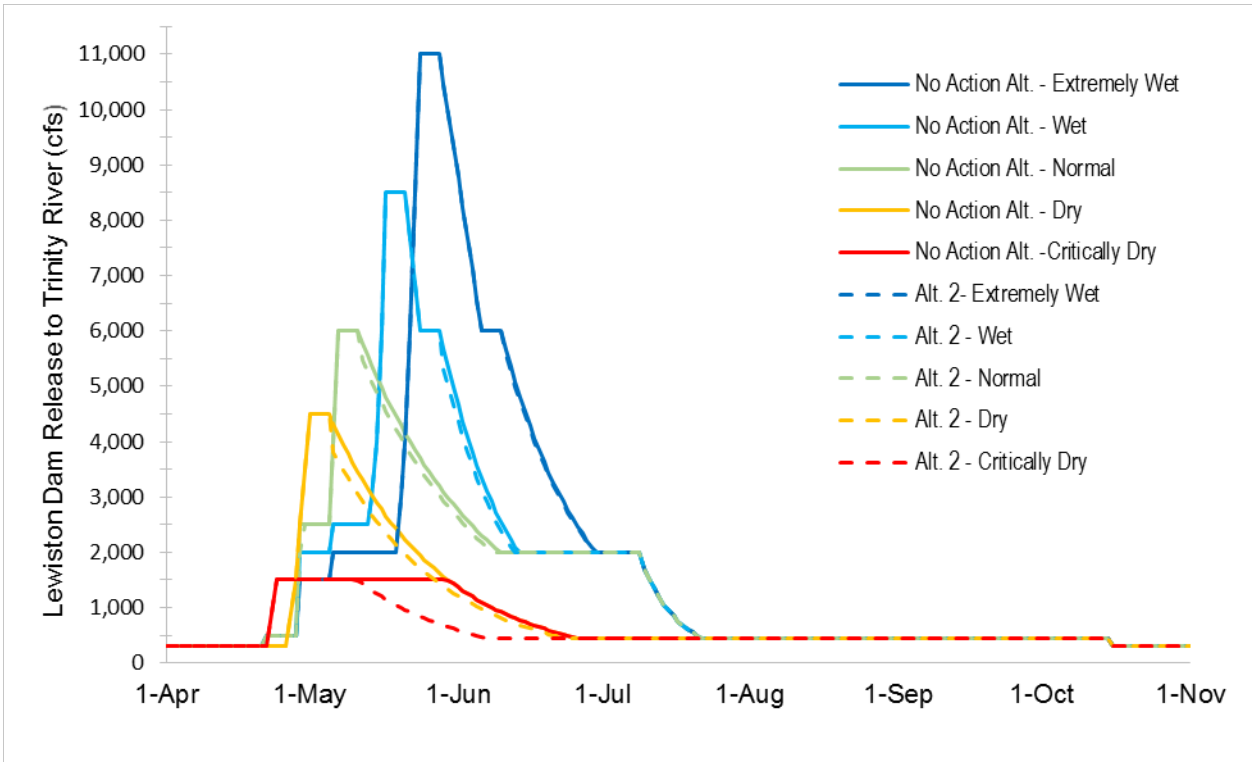
Under Alternative 2, Trinity River ROD flow releases would be reduced in earlier months to reserve a portion of the total release volume, to meet the estimated need for supplemental flows later in the season. Table ES-2 identifies the volume of water, based on the Trinity River ROD year type, to be rescheduled for release in August and September for flow augmentation.

Table ES-2. Trinity River ROD Flow Volumes by Water Year Type

Water Year Classification	Total Trinity Reservoir Inflow for Water Year Classification[1] (acre-feet)	Total Volume of Trinity River ROD Flows[1] (acre-feet)	Volume Rescheduled for Alternative 2[2] (acre-feet)
Extremely Wet	>=2,000,000	815,000	3,228
Wet	1,350,000-1,999,999	701,000	7,593
Normal	1,025,000-1,349,999	647,000	10,536
Dry	650,000-1,024,999	453,000	23,476
Critically Dry	<650,000	369,000	33,261

Notes:
[1] As described in the 2000 *Final Trinity Mainstem Fishery Restoration Environmental Impact Statement/Report*
[2] Volumes reflect average estimated preventive base flow augmentation by year type based upon CalSim inputs
Key:
ROD = Record of Decision

Figure ES-2 shows how the pattern of Trinity River ROD flows would be rescheduled during each year type, by reducing the flows early in the year to provide a reserve for release in August and September for flow augmentation. The Trinity Management Council will continue to guide the Adaptive Environmental Assessment and Management Program, recommending possible adjustments to the annual flow schedule (within the designated flow volumes provided in Table ES-2) to ensure that the restoration and maintenance of the Trinity River anadromous fishery continues, based on the best available scientific information and analysis.



Key:
Alt = Alternative

Figure ES-2. Rescheduling of Trinity River ROD Flow Release Pattern for All Year Types Under Alternative 2

The annual implementation schedule for Alternative 2 would be the same as described for the Proposed Action (Alternative 1). Monitoring and research actions would be the same as those described for the Proposed Action (Alternative 1).

Issues to be Resolved

Principle among the issues that will be resolved in choosing a preferred alternative is how and what water will be used to meet any additional flows released into the Trinity River and subsequently the lower Klamath River. Another issue is the use of available science to guide the release of water, to inform the development and implementation of an effective adaptive

management strategy, and to identify potential mitigation for impacts associated with implementing the preferred alternative. Reclamation has not yet chosen a preferred alternative, and will consider comments received on the Draft EIS, in conjunction with the impact analysis contained in the Draft EIS, when making a decision.

The Trinity River ROD provides for adjustments to the annual flow schedule within the designated flow volumes approved by the Trinity Management Council. If Reclamation were to approve Alternative 2 as the preferred alternative, an issue was raised regarding Reclamation's ability to implement Alternative 2. Specifically, the issues are Reclamation's ability to modify the annual flow schedule by reducing the flows early in May and June to provide a reserve for release in August and September, and the subsequent disposition of unused water.

Areas of Controversy

Tribal, Federal, State, and local stakeholders have identified several areas of controversy during public and stakeholder outreach activities. The areas of controversy are: scientific uncertainty regarding causative factors of Ich outbreaks and potential fish die-off; associated flow augmentation trigger criteria; and selection of water sources for flow augmentation, including the use of Trinity River ROD flows.

Impact Analysis

Both Alternatives 1 and 2 have the ability to meet the Purpose and Need, though each alternative would require coordination from a host of agencies and interested parties to implement. Though both alternatives have similar environmental effects, the main differences between the alternatives are the effects on CVP water deliveries, temperature effects in the Trinity and Sacramento Rivers, and the effects to hydropower generation. In general, in some drier years, Alternative 1 would reduce CVP water deliveries by up to 24 TAF, while Alternative 2 would reduce those same deliveries by about 6 TAF. Both alternatives could lead to water temperature changes in the mainstem of the Trinity River, with Alternative 1 having effects primarily in July through December while Alternative 2 would have effects on water temperature in April through July. Alternative 1 would also have effects on water temperatures in the Sacramento River, which could affect various life stages for Chinook Salmon in critical years. In addition, both alternatives would change hydropower generation, with Alternative 1 having the maximum decrease in TRD energy production of 9.8 gigawatt-hours in critical years. Details of these differences are provided in each EIS resource chapter, and are summarized below in Table ES-3.

Table ES-3. Comparison of Environmental Effects of Alternatives 1 and 2

Alternative 1 Compared to the No Action Alternative	Alternative 2 Compared to the No Action Alternative
Surface Water Supply and Management	
Trinity River	*Trinity River*
Lewiston Dam flow releases to the Trinity River would increase in August and September in all year types with a maximum increase of 115% in September of critically dry years. In addition, due to reduced spills, Trinity River flows below Lewiston Dam would decrease by 10% in November of extremely wet years, 10% in October of critically dry years, and 7% in February of normal years. Lewiston Dam flow releases would be similar to the No Action Alternative during other months and year types (less than a 5% change).	Lewiston Dam flow releases to the Trinity River would increase in August and September in all year types with a maximum increase of 132% in September of critically dry years. Reductions in Lewiston Dam releases occur in most year types in May and June with the larger reductions in the drier years (up to 38% reduction in June of critically dry years). In addition, due to reduced spills, Trinity River flows below Lewiston Dam decrease by 8% in November of extremely wet years and 6% in February of normal years. Lewiston Dam flow releases would be similar to the No Action Alternative during other months and year types (less than a 5% change).
Trinity Lake storage would be similar to the No Action Alternative, with 4% or less change in all months and year types with the maximum change of a 4% decrease in September of critically dry years.	Trinity Lake storage would be similar to the No Action Alternative, with 4% or less change in all months and year types with the maximum change of a 4% increase in June of critically dry years.
Trinity Lake elevation would be similar to the No Action Alternative with changes less than, or equal to, 1% in all months and year types.	Effects would be comparable to Alternative 1.
Long-term average TRD diversions from Lewiston Reservoir to the Sacramento Basin would be reduced by 13 TAF per year.	Long-term average TRD diversions from Lewiston Reservoir to the Sacramento Basin would be reduced by less than 1 TAF per year
Lower Klamath River	*Lower Klamath River*
Flows in the lower Klamath River, at Klamath, would increase in August and September in most year types with a maximum increase of 69% in September of critically dry years. In all other months and year types, changes were 1% or less.	Flows in the lower Klamath River, at Klamath, would increase in August and September in most year types with a maximum increase of 69% in September of critically dry years. Flows would be reduced in May and June of dry and critically dry years, with reductions up to 9% in June of critically dry years. In all other months and year types, changes were 1% or less.
Clear Creek, Sacramento River, Feather River, American River, and Stanislaus River	*Clear Creek, Sacramento River, Feather River, American River, and Stanislaus River*
Storage levels in Whiskeytown Lake, Shasta Lake, Lake Oroville, Folsom Lake, and New Melones Lake would be similar to the No Action Alternative with changes less than, or equal to, 2% in all months and year types.	Effects would be comparable to Alternative 1.

Table ES-3. Comparison of Environmental Effects of Alternatives 1 and 2 (contd.)

Alternative 1 Compared to the No Action Alternative	Alternative 2 Compared to the No Action Alternative
Surface Water Supply and Management (contd.)	
Clear Creek, Sacramento River, Feather River, American River, and Stanislaus River	*Clear Creek, Sacramento River, Feather River, American River, and Stanislaus River*
Water elevation levels in Whiskeytown Lake, Shasta Lake, Lake Oroville, Folsom Lake, and New Melones Lake would be similar to the No Action Alternative with changes less than 1% in all months and year types.	Effects would be comparable to Alternative 1.
Flows in Clear Creek, and the Sacramento, Feather, American, and Stanislaus Rivers, downstream of CVP and SWP dams, would be similar to the No Action Alternative with changes less than, or equal to, 5% in all months of all year types, except for increases in Feather River flows of 6% in critical years.	Effects would be comparable to Alternative 1.
Sacramento-San Joaquin Delta Inflow and Outflow	*Sacramento-San Joaquin Delta Inflow and Outflow*
Sacramento River inflow to the Delta, San Joaquin River inflow to the Delta, and Delta outflow would be similar to the No Action Alternative with changes of less than 1% in all months of all year types.	Effects would be comparable to Alternative 1.
Old and Middle River Flow (OMR)	*Old and Middle River Flow (OMR)*
OMR conditions would be similar to the No Action Alternative in all months of all year types with reductions up to 3%, except for increases of 6% in June of critical years.	OMR conditions would be similar to the No Action Alternative in all months of all year types with reductions up to 2%, except for increases of 6% in June of critical years.
Jones (CVP Exports) Pumping Plant	*Jones (CVP Exports) Pumping Plant*
Exports at Jones Pumping Plant would be similar to the No Action Alternative with changes less than, or equal to, 3% in all months of all year types, except for reductions of 7% in June of critical years.	Exports at Jones Pumping Plant would be similar to the No Action Alternative with changes less than, or equal to, 4% in all months of all year types.
Total CVP Deliveries	*Total CVP Deliveries*
Long-term average CVP water deliveries would be similar to the No Action Alternative with changes in all year types of less than 1%, with an average reduction of 13 TAF. This represents reductions of 22 TAF in critical years, 24 TAF in dry years, 13 TAF in below normal years, 4 TAF in above normal years, and 4 TAF in wet years.	Total CVP water deliveries would be similar to the No Action Alternative with changes to all contractors in all year types of less than 1%, with an average increase of 1 TAF. Changes by year type range from an increase of 4 TAF in above normal years to a decrease of 6 TAF in critical years.

Table ES-3. Comparison of Environmental Effects of Alternatives 1 and 2 (contd.)

Alternative 1 Compared to the No Action Alternative	Alternative 2 Compared to the No Action Alternative
Surface Water Quality	
Trinity River and Lower Klamath River	*Trinity River and Lower Klamath River*
The number of days in compliance with the temperature objectives for the Trinity River under the NCRWQCB Basin Plan and SWRCB Order WR-90-5 would decrease by approximately 1% (from 93% to 92% of the time) compared to the No Action Alternative.	The number of days of compliance with the temperature objectives for the Trinity River under the NCRWQCB Basin Plan and SWRCB Order WR-90-5 would be comparable to the No Action Alternative (both Alternative 2 and No Action Alternative would meet objectives 93% of the time).
The number of days that Trinity River temperatures below Lewiston Dam would meet temperature objectives identified in the Trinity River ROD would be similar to the No Action Alternative (both Alternative 1 and No Action Alternative would meet objectives 99% of the time).	Effects would be comparable to Alternative 1.
The number of days that Trinity River temperatures at Weitchpec would meet temperature objectives identified in the Trinity River ROD would be similar to the No Action Alternative (both Alternative 1 and the No Action meet objectives 69% of the time).	The number of days that Trinity River temperatures at Weitchpec would meet temperature objectives identified in the Trinity River ROD would decrease by approximately 2% in comparison to the No Action Alternative (from 69% to 67% of the time).
Water temperatures in the Trinity River would be similar to the No Action Alternative, with most months of the year changing by less than 1%. Exceptions occur in July (up to 5% increase) of critically dry years in the upper sections of the river; August (up to 4% decrease) of critically dry, dry and normal years); and September (3 to 9% decrease) of critically dry, dry and normal years).	Water temperatures in the Trinity River would be similar to the No Action Alternative, with most months of the year changing by less than 1%. Exceptions occur in June (up to 2% increase) of critically dry years; August (up to 4% decrease) of critically dry, dry and normal years); and September (3 to 9% decrease) of critically dry, dry and normal years).
Water temperatures in the lower Klamath River would be similar to the No Action Alternative, with most months of the year changing 1% or less. Exceptions occur in August (reductions of 2%) in critically dry and normal years, and in September (reductions of 3% to 6%) of critically dry, dry, and normal years.	Effects would be comparable to Alternative 1.
Nutrient concentrations, organic matter concentrations, and dissolved oxygen in the lower Klamath River would be similar to the No Action Alternative during most months and year types. Lower nutrient and organic matter concentrations are anticipated in August and September during flow augmentation actions, particularly in drier years.	Effects would be comparable to Alternative 1.

Table ES-3. Comparison of Environmental Effects of Alternatives 1 and 2 (contd.)

Alternative 1 Compared to the No Action Alternative	Alternative 2 Compared to the No Action Alternative
Surface Water Quality (contd.)	
Sacramento River and Clear Creek Water temperatures on the Sacramento River below Clear Creek, and at Balls Ferry, Jellys Ferry, and Bend Bridge, would be similar to the No Action Alternative with all months of all year types changing less than, or equal to, 1%. Water temperatures on Clear Creek at Igo would be similar to the No Action Alternative with all months of all year types changing less than, or equal to, 1%. *Delta Salinity and X2 Position* X2 Position and salinities in the Delta at Rock Slough, Emmaton, Jersey Point, Collinsville, and at Banks and Jones Pumping Plants would be similar to the No Action Alternative with all months of all year types changing less than, or equal to, 1%.	*Sacramento River and Clear Creek* Effects would be comparable to Alternative 1. *Delta Salinity and X2 Position* Effects would be comparable to Alternative 1.
Groundwater Resources/Groundwater Quality	
Groundwater use and elevation, land subsidence, and groundwater quality would be similar to the No Action Alterative for all year types except critical years. In portions of the Sacramento and San Joaquin Valleys, reduced surface water deliveries could increase demands on groundwater and potentially adversely impact groundwater use and elevation, groundwater levels, subsidence and water quality.	No effects on groundwater resources/groundwater quality. Groundwater use and elevation, land subsidence, and groundwater quality would be similar to the No Action Alterative for all year types.
Biological Resources – Fisheries	
Klamath and Trinity Rivers and Trinity Lake <u>Coho Salmon, Spring-run Chinook Salmon, Fall-run Chinook Salmon, and Steelhead</u> Late-summer pulse flows could increase juvenile stranding for Coho Salmon, spring-run Chinook Salmon and steelhead, and spring-run Chinook salmon holding and redd dewatering. Water temperatures meet the temperature objectives for adult migration, juvenile rearing, and outmigration in a similar pattern as the No Action Alternative, with the difference in the number of days exceeding the objectives at less than 5 percent.	*Klamath and Trinity Rivers and Trinity Lake* <u>Coho Salmon, Spring-run Chinook Salmon, Fall-run Chinook Salmon, and Steelhead</u> Effects would be comparable to Alternative 1. Water temperatures meet the temperature objectives for adult migration, juvenile rearing, and outmigration in a similar pattern as the No Action Alternative, with the difference in the number of days exceeding the objectives at less than 2 percent. Spawning and adult migration would not be affected by changes in fall temperatures under Alternative 2.

Table ES-3. Comparison of Environmental Effects of Alternatives 1 and 2 (contd.)

Alternative 1 Compared to the No Action Alternative	Alternative 2 Compared to the No Action Alternative
Biological Resources – Fisheries (contd.)	
Klamath and Trinity Rivers and Trinity Lake	*Klamath and Trinity Rivers and Trinity Lake*
Coho Salmon, Spring-run Chinook Salmon, Fall-run Chinook Salmon, and Steelhead Rearing habitat availability high up on alluvial bars would be similar to the No action alternative	Coho Salmon, Spring-run Chinook Salmon, Fall-run Chinook Salmon, and Steelhead Habitat availability high up on alluvial bars (used by fry and juvenile salmonids for rearing) would be similar under Alternative 2 compared to the No Action Alternative, except for approximately two weeks during May and June in critically dry years. Low recession rates would remain gradual enough to allow for fish to move from side-channels and off-channel areas into the main river channel as flows decline.
The risk of Ich infection, epizootic events, and fish die-offs would be reduced compared to the No Action Alternative through increased habitat area, increased water velocities, improved migration cues, and a decrease in frequency of water temperatures exceeding 73.4°F.	Effects would be comparable to Alternative 1.
Pacific Lamprey Late summer augmentation flows may increase water velocities, causing juvenile lamprey to redistribute.	Pacific Lamprey Effects would be comparable to Alternative 1.
Eulachon Affects to flows in the lower Klamath River and Estuary would be similar between Alternative 1 and the No Action Alternative.	Eulachon Effects would be comparable to Alternative 1.
Reservoir Fishes Reservoir fish habitat, for both cold water and warm water in Trinity Lake, would be similar between Alternative 1 and the No Action Alternative.	Reservoir Fishes Effects would be comparable to Alternative 1.
Central Valley and Bay-Delta	*Central Valley and Bay-Delta*
Chinook Salmon and Steelhead SALMOD results indicate some critical years may result in decreased production of Chinook Salmon compared with the No Action Alternative. Overall averages show similar production levels (less than 3%) for all runs of Chinook Salmon (and through similar life stages, steelhead), except for fall-run Chinook Salmon which experience a higher potential mortality rate in critical water years (averaging 6% reduced survival) and spring-run, which experience a greater than 5% increase in survival in critical water years.	Chinook Salmon and Steelhead SALMOD results indicate some critical years may result in decreased production of Chinook Salmon compared with the No Action Alternative, however, the overall averages show similar production levels (less than 3% reduction) for all four runs of Chinook Salmon (and through similar life stages, steelhead).

Table ES-3. Comparison of Environmental Effects of Alternatives 1 and 2 (contd.)

Alternative 1 Compared to the No Action Alternative	Alternative 2 Compared to the No Action Alternative
Biological Resources – Fisheries (contd.)	
Central Valley and Bay-Delta	*Central Valley and Bay-Delta*
Chinook Salmon and Steelhead IOS results indicate winter-run Chinook Salmon would experience reduced survival during several critical water years, resulting in a less than 1% average reduction in spawning escapement, a 9% reduction in fry-to-smolt survival and 5% reduction in smolt production under Alternative 1. However, the average overall affects to winter-run Chinook Salmon are similar with a less than 1% reduction in spawning escapement to the No Action Alternative.	Chinook Salmon and Steelhead IOS results indicate winter-run Chinook Salmon would experience reduced survival during several critical water years, but the overall spawning escapement in critical water years would increase by about 2%. The average overall affects to winter-run Chinook Salmon are similar with a less than 1% reduction in spawning escapement to the No Action Alternative.
Water temperatures would be generally similar at temperature compliance locations in the upper Sacramento River compared to the No Action Alternative, except in critical water years in the Sacramento River below Clear Creek, Balls Ferry, and Jellys Ferry.	Water temperatures would be generally similar at temperature compliance locations in the upper Sacramento River compared to the No Action Alternative.
The WUA in the Sacramento, Feather and American Rivers and Clear Creek for Chinook Salmon and steelhead spawning, fry rearing, and juvenile rearing would be generally similar (less than 1% change) for suitable habitat to the No Action Alternative.	Effects would be comparable to Alternative 1.
Based on Delta hydrodynamics, habitat conditions and entrainment would be similar to the No Action Alternative.	Effects would be comparable to Alternative 1.
Green Sturgeon River water temperatures and Delta hydrodynamics suitable for Green Sturgeon would be similar to the No Action Alternative.	Green Sturgeon Effects would be comparable to Alternative 1.
Delta Smelt Habitat conditions (based on Delta hydrodynamics) and entrainment would be similar to the No Action Alternative.	Delta Smelt Effects would be comparable to Alternative 1.
Reservoir Fishes Reservoir fish habitat conditions for both cold water and warm water fishes would be similar in Whiskeytown Lake, Shasta Lake, Oroville Lake and Folsom Lake to the No Action Alternative.	Reservoir Fishes Effects would be comparable to Alternative 1.

Table ES-3. Comparison of Environmental Effects of Alternatives 1 and 2 (contd.)

Alternative 1 Compared to the No Action Alternative	Alternative 2 Compared to the No Action Alternative
Biological Resources – Terrestrial	
Trinity Lake and Trinity River Terrestrial resources at Trinity Lake and on the Trinity River would be similar to the No Action Alternative for most months and year types, except for: minor adverse effects on terrestrial wildlife species at Trinity Lake in September of critically dry water years due to decreased storage elevation; minor effects to Yellow-legged Frog and Western Pond Turtle from changes in flow and water temperature in Trinity River in late summer; and temporary minor positive effects on riparian terrestrial habitat and terrestrial wildlife on the Trinity River in August and September due to increased flows.	*Trinity Lake and Trinity River* Terrestrial resources at Trinity Lake and on the Trinity River would be similar to the No Action Alternative for most months and year types, except for: minor positive effects on terrestrial wildlife species at Trinity Lake during June through August of critical water years due to increased storage elevation and minor adverse effects in September in these years due to decreased storage elevation; minor adverse effect on terrestrial resources on Trinity River in May and June of critically dry water years due to flow reductions which may hinder TRRP efforts to control riparian vegetation; minor positive effect on Foothill Yellow-legged Frog breeding success and tadpole development, and Western Pond Turtles young-of-the-year and juveniles resulting from increased water temperatures in critically dry years; and minor effects to Yellow-legged Frog and Western Pond Turtle from changes in flow and water temperature in Trinity River in August and September.
Klamath River Terrestrial resources on the lower Klamath River would be similar to the No Action Alternative for most months and year types except for minor positive effects on riparian terrestrial habitat and terrestrial wildlife in August and September due to increased flows.	*Klamath River* Terrestrial resources on the lower Klamath River would be similar to the No Action Alternative for most months and year types, except for: minor adverse effect on terrestrial resources in late May and early June of critically dry water years due to reduction of Trinity River ROD flows; and temporary positive effects on riparian terrestrial habitat and terrestrial wildlife in the August and September due to increased flows.
Sacramento Valley Minor positive effects on terrestrial resources on the Feather River in June of critical water years and on the American River in September of critical water years. Alternative 1 would reduce habitat for Sacramento Valley wildlife which utilize agricultural lands due to reduced water supplies in critical water years.	*Sacramento Valley* Effects would be comparable to Alternative 1. Alternative 2 would have similar habitat for Sacramento Valley wildlife which utilize agricultural lands.

Table ES-3. Comparison of Environmental Effects of Alternatives 1 and 2 (contd.)

Alternative 1 Compared to the No Action Alternative	Alternative 2 Compared to the No Action Alternative
Hydropower Generation	
CVP and SWP annual energy generation, energy use, and net energy generation would be similar (less than 1% change). Long-term average decrease of 13.5 GWh in net energy generation for the CVP and SWP. Long-term average decrease of TRD generation by 7 GWh (1% change), with a maximum decrease of 9.8 GWh (2.5% change) in critical years.	CVP and SWP annual energy generation, energy use, and net energy generation would be similar (less than 1% change). Long-term average decrease of 3.7 GWh in net energy generation for the CVP and SWP. Long-term average change in TRD generation would be similar between Alternative 2 and the No Action Alternative, with a maximum decrease of 5.2 GWh (0.6% change) in wet years and a maximum increase of 9.8 GWh (1.4% change) in below normal years.
Air Quality, Greenhouse Gas Emissions and Global Climate Change	
Average annual increase in GHG emissions of 6,720 MT CO_2e in comparison to the No Action Alternative.	Average annual increase in GHG emissions of 1,857 MT CO_2e in comparison to the No Action Alternative.
Agricultural Resources	
Agricultural resources would be similar to the No Action Alternative. Changes in irrigated acreage and agricultural production would be less than 1% for all year types in the Sacramento and San Joaquin Valleys.	Effects would be comparable to Alternative 1.
Socioeconomics	
Lower Klamath and Trinity Rivers	*Lower Klamath and Trinity Rivers*
Commercial, sport, and tribal fishing opportunities would be improved due to the reduced likelihood of an Ich outbreak and associated fish-die off.	Effects would be comparable to Alternative 1.
Recreational economic factors related to the use of Trinity Lake would be similar.	Effects would be comparable to Alternative 1.
Recreational economic factors would be similar downstream of Lewiston Dam on the Trinity River and lower Klamath River.	Effects would be comparable to Alternative 1.
Central Valley and Bay-Delta	*Central Valley and Bay-Delta*
Agricultural water-related employment would be similar.	Effects would be comparable to Alternative 1.
Recreational economic factors in the use of CVP reservoirs would be similar.	Effects would be comparable to Alternative 1.

Table ES-3. Comparison of Environmental Effects of Alternatives 1 and 2 (contd.)

Alternative 1 Compared to the No Action Alternative	Alternative 2 Compared to the No Action Alternative
Indian Trust Assets	
There are no substantial adverse effects to ITAs related to water, fisheries resources and terrestrial biological resources.	Effects would be comparable to Alternative 1.
Environmental Justice	
No disproportionately high and adverse effects on low-income or minority populations or Indian tribes.	Effects would be comparable to Alternative 1.

Key:
% = percent
CVP = Central Valley Project
CO_2e = carbon dioxide equivalent
Delta = Sacramento-San Joaquin River Delta
GHG = greenhouse gas emissions
GWh = gigawatt-hours
IOS = Interactive Object-Oriented Simulation
ITA = Indian Trust Asset
NCRWQCB = North Coast Regional Water Quality Control Board
MT = metric tons
OMR = Old and Middle River
ROD = Record of Decision
SWP = State Water Project
SWRCB = State Water Resources Control Board
TAF = thousand acre-feet
TRD = Trinity River Division
TRRP = Trinity River Restoration Program

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Abbreviations and Acronyms

°C	degrees Celsius
°F	degrees Fahrenheit
AB	California Assembly Bill
ACID	Anderson-Cottonwood Irrigation District
ACS	American Community Survey
ARB	California Air Resource Board
Banks Pumping Plant	Harvey O. Banks Pumping Plant
BEA	U.S. Bureau of Economic Analysis
BIA	Bureau of Indian Affairs
BLM	U.S. Bureau of Land Management
BLS	U.S. Bureau of Labor Statistics
BO	Biological Opinion
BSPP	Barker Slough Pumping Plant
CAAQS	California Ambient Air Quality Standards
CBOD	Carbonaceous Biochemical Oxygen Demand
CCF	Clifton Court Forebay
CCWD	Contra Costa Water District
CDFG	California Department of Fish and Game
CDFW	California Department of Fish and Wildlife
CEC	California Energy Commission
CEQ	Council on Environmental Quality
CEQA	California Environmental Quality Act
CESA	California Endangered Species Act
CFR	Code of Federal Regulations
cfs	cubic feet per second
CH_4	methane
CNDDB	California Natural Diversity Database
CNPS	California Native Plant Society
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
COA	Coordinated Operation Agreement
Columnaris	*Flavobacter columnare*
CPUC	California Public Utilities Commission
CRPR	California Rare Plant Ranks
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
CVRWQCB	Central Valley Regional Water Quality Control Board
D-1641	Decision 1641
DAT	daily average temperatures

DCC	Delta Cross Channel
Delta	Sacramento-San Joaquin River Delta
DFG	Department of Fish and Game
DMC	Delta-Mendota Canal
DO	dissolved oxygen
DOI	U.S. Department of the Interior
DPS	distinct population segment
Draft LTP	Draft Long-Term Plan for Protecting Late Summer Adult Salmon in the Lower Klamath River
DWR	California Department of Water Resources
EA	Environmental Assessment
EC	electrical conductivity
EDD	California Employment and Development Department
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
EO	Executive Order
EOM	end-of-month
ESA	Federal Endangered Species Act
ESU	Evolutionarily Significant Unit
FERC	Federal Energy Regulatory Commission
FMWT	Fall Midwater Trawl Survey
FONSI	Finding of No Significant Impact
FR	Federal Register
FWCA	Fish and Wildlife Coordination Act
GCID	Glenn-Colusa Irrigation District
GHG	greenhouse gas
GPS	Global Positioning System
GSP	Groundwater Sustainability Plan
GWh	gigawatt-hours
HFC	hydrofluorocarbons
HWG	Hydropower Working Group
Ich	*Ichthyophthirius multifiliis*
IFIM	Instream Flow Incremental Methodology
IM 15	Interim Measure 15
IMPLAN	IMpact analysis for PLANning
IOS	Interactive Object-Oriented Simulation
IPCC	Intergovernmental Panel on Climate Change
ITA	Indian Trust Asset
Jones Pumping Plant	C.W. Jones Pumping Plant
KBAO	Klamath Basin Area Office
KFHAT	Klamath Fish Health Assessment Team

KRRC	Klamath River Renewal Corporation
LTP	Long-Term Plan to Protect Adult Salmon in the Lower Klamath River
M&I	municipal and industrial
MAF	million acre-feet
MMPA	Marine Mammal Protection Act
msl	mean sea level
MT	metric tons
MW	megawatts
MWh	megawatt-hours
N_2O	nitrous oxide
NAAQS	National Ambient Air Quality Standards
NAS	National Academy of Sciences
NASS	National Agricultural Statistics Service
NCAO	Northern California Area Office
NCRWQCB	North Coast Regional Water Quality Control Board
NEPA	National Environmental Policy Act
NFH	National Fish Hatchery
NMFS	National Marine Fisheries Service
NOA	Notice of Availability
NOAA	National Oceanic and Atmospheric Administration
NOD	North-of-Delta
NOI	Notice of Intent
NWR	National Wildlife Refuge
OCAP	Operations Criteria and Plan
OMR	Old and Middle River
PCE	primary constituent element
PFC	perfluorocarbons
PFMC	Pacific Fishery Management Council
PL	Public Law
RBPP	Red Bluff Pumping Plant
Reclamation	U.S. Department of the Interior, Bureau of Reclamation
RM	river mile
ROD	Record of Decision
RPA	Reasonable and Prudent Alternative
RPS	California Renewables Portfolio Standard
RWQCB	Regional Water Quality Control Board
SB	Senate Bill
SF_6	sulfur hexafluoride
SGMA	Sustainable Groundwater Management Act
SLDMWA	San Luis & Delta-Mendota Water Authority
SOD	South-of-Delta

SONCC	Southern Oregon/Northern California Coast
Subgroup	Lower Klamath River Flow Augmentation Subgroup
SWAP	Statewide Agriculture Production
SWP	State Water Project
SWRCB	State Water Resources Control Board
TAF	thousand acre-feet
TCD	temperature control device
TDS	total dissolved solids
TEPA	Tribal Environmental Protection Agency
TMC	Trinity Management Council
TMDL	Total Maximum Daily Load
TN	total nitrogen
TP	total phosphorus
TRD	Trinity River Division
TRFE	Trinity River Flow Evaluation
TRRP	Trinity River Restoration Program
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
Western	Western Area Power Administration
WSEL	reservoir water surface elevation
WUA	Weighted Usable Area
YOY	young-of-the-year
YTFP	Yurok Tribal Fisheries Program

Chapter 1
Introduction

Background and History

In September 2002, an unforeseen and unprecedented fish die-off occurred during a two-week period in the lower Klamath River (Reclamation 2015a). A subsequent U.S. Fish and Wildlife Service (USFWS) report indicated that of the approximately 34,000 anadromous salmonids estimated to have perished during this event, nearly all (98.4 percent) were adult salmonids. Of this total, 97 percent (~33,000) were fall-run Chinook Salmon, 1.8 percent (~629) were steelhead, and 1.0 percent (344) were Coho Salmon. The two fish disease pathogens leading to the die-off were identified as *Ichthyophthirius multifiliis* (Ich) and *Flavobacter columnare* (Columnaris) (USFWS 2003).[1] High fish densities—due to the relatively large run size (approximately 170,000 adult Chinook Salmon), low flows, and relatively high water temperatures—were identified as causative factors for the rapid spread of disease. Although a larger number of Klamath River fall-run Chinook Salmon died, a greater proportion of the Trinity River run was lost because the die-off occurred during the peak migration of the Trinity River fish (DFG 2004). Since 2002 the U.S. Department of the Interior, Bureau of Reclamation (Reclamation) has been working with local tribes, resource agencies, and the public to protect fall-run Chinook Salmon returning to the Klamath and Trinity Rivers.

In 2003 and 2004 the Klamath River Chinook Salmon run sizes varied significantly with post-return estimates of approximately 192,000 adults and just under 79,000 adults, respectively, as shown in Table 1-1. As shown in Figure 1-1, to avert another die-off, Reclamation made preventative releases from Trinity Reservoir, part of the Reclamation's Central Valley Project (CVP), in the late summer of both years, totaling 38,000 and 36,313 acre-feet, respectively, to improve fish habitat conditions in the lower Klamath River. The majority of that combined volume was acquired through an exchange with the Metropolitan Water District of Southern California.[2] There was no substantial disease outbreak noted by tribal, Federal, or State fishery resource agencies during these return periods.

[1] Both diseases are infectious and the pathogens are naturally present in low concentrations during much of the year in many rivers and streams. Historically, small numbers of fish are infected by one or both diseases during years with normal or above-normal hydrology. The free-swimming protozoan life stage of Ich is opportunistic, however, and spreads more rapidly among fish that are in close proximity in slow-moving water. In such instances, large numbers of protozoans attach to gill arches, inhibiting respiration, which can prove fatal.

[2] Though Metropolitan Water District of Southern California sought return of the exchange volume in years immediately after the 2003-2004 exchange, it was not until 2009 that the exchanged volume was fully repaid, delayed primarily by Delta conveyance constraints.

Table 1-1. Summary of Hydrologic and Biological Conditions in the Lower Klamath River for Years with Fish Die-Off or Flow Augmentation Releases

Year	Post Season Adult Fall-Run Chinook Salmon Run Size	Ich Counts	Average Flows at Klamath, California in August and September Excluding Flow Augmentation Releases (cfs)	Observed Fish Die-off	Flow Augmentation Action Implemented
2002	170,000	Not Available	2,160	Yes	No
2003	192,000	Counts > 50 observed	3,100	No	Yes
2004	79,000	0	2,670	No	Yes
2012	292,000	0	2,890	No	Yes
2013	165,100	0	2,890	No	Yes
2014	160,000	Counts > 600 observed	2,160	No	Yes
2015	83,800	Maximum counts > 600	2,200	No	Yes

Note:
[1] Counts are qualified by criteria where low-level infection (less than 30 Ich trophonts per gill arch) occur in the first two weeks of September on three adult salmon in one day.

Key:
cfs = cubic feet per second

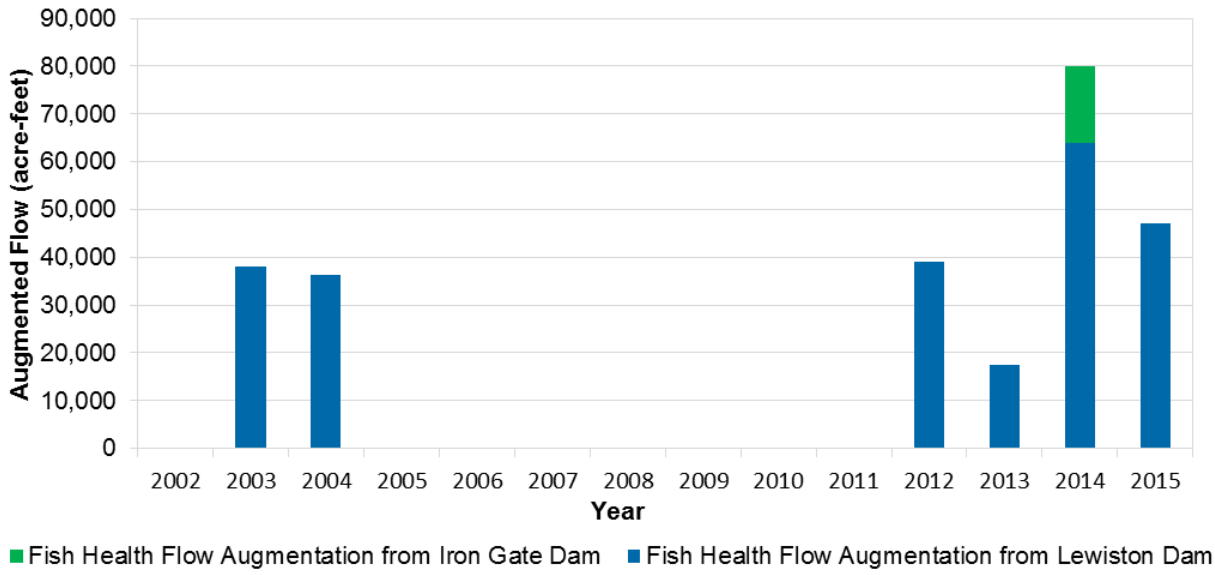

Figure 1-1. Flow Augmentation Releases Made by Reclamation and PacifiCorp from 2003 to 2015 to Reduce the Prevalence of Fish Disease in the Lower Klamath River

Predicted very dry hydrologic conditions in the Klamath River Basin in 2008 and 2009 again triggered concerns regarding adult fish health. Reclamation prepared to make augmentation releases and consulted with tribes and other Klamath and Trinity River Basin partners to develop biological and hydrologic criteria. Hydrologic conditions later improved to the extent that

preventative actions were ultimately unnecessary. Adult fall-run Chinook Salmon post-return estimates during 2008 and 2009 totaled 70,698 and 100,644, respectively.

In March of 2012, the Pacific Fishery Management Council (PFMC) announced its in-river, run-size projection for Klamath River fall Chinook Salmon of 384,000 adults; the highest estimate, by a considerable margin, since recordkeeping began in 1978 (PFMC 2013).[3] Abnormally dry hydrologic conditions led to very low Klamath River accretion forecasts, prompting concerns of a disease outbreak. Tribes, sport-fishing groups, and other fishery advocates formally requested that Reclamation take action.

In response, Reclamation collaborated with tribes, regulatory agencies, and other basin partners to develop and refine monitoring and flow augmentation criteria. A Lower Klamath River Flow Augmentation Subgroup (Subgroup) of the Flow Workgroup, (affiliated with the Trinity River Restoration Program (TRRP) was established among the partners and met on many occasions. The Subgroup reviewed past analyses, researched contemporary disease propagation information, and studied hydrologic data. Ultimately, the Subgroup summarized their recommendations in a memorandum, 2012 *Fall Flow Release Recommendation*, to the Trinity Management Council (TMC)[4] Chair, dated May 31, 2012 (Trinity River Restoration Program 2012). Their primary recommendations were two-fold:

- As a preventative measure, they recommended that flows in the lower Klamath River be augmented to at least 3,200 cubic feet per second (cfs) beginning August 15, 2012, and continuing through September 21, 2012, at a minimum, or until river water temperatures were reduced to below 23 degrees Celsius (°C); and,

- They recommended enhanced monitoring of fish for indicators of disease, and as an emergency flow augmentation measure, if such indicators were above a predetermined threshold as documented by the Fish Health Center, that flows in the lower Klamath River be doubled to a maximum of 6,400 cfs for a period of 7 days.

Reclamation prepared an Environmental Assessment (EA) and on August 10, 2012, signed a Finding of No Significant Impact (FONSI) for the release of up to 44,800 acre-feet to augment flows in the lower Klamath River for preventative purposes, along with up to 48,000 acre-feet exclusively from Trinity Reservoir for emergency flow augmentation purposes if monitoring indicated that this was necessary. Klamath River Basin hydrologic conditions had deteriorated over the course of the analysis, precluding additional releases from the Klamath River Basin, whereas Trinity Reservoir storage in mid-summer was at 107 percent of the 15-year average.

In addition to collaborating with partners in formulating the action, Reclamation consulted with water user and power customer representatives prior to releasing the EA and again prior to executing the FONSI. Ultimately, 39,000 acre-feet was released for preventative purposes and no

[3] The highest previous run size during the period of record was 222,800 adults in 1995. The actual 2012 run size was 302,000 adults, and while it was 21 percent below the PFMC projection, it still represents a modern-day record.

[4] The TMC is prescribed by the ROD for the Trinity River Mainstem Fisheries Restoration EIS/EIR to guide overall implementation of the TRRP. Comprised of eight members representing two tribes, Trinity County, the State of California, and four Federal agencies, the TMC makes decisions by super majority, meaning that at least seven aye votes are required to pass a formal motion.

emergency releases were required. There was no substantial disease outbreak noted by tribes or fishery resource agencies during the return period. The fall-run Chinook Salmon return, post-season estimate was 292,000 adults.

From 2013 through 2015, the Klamath Basin experienced drought conditions. During this period, below-average precipitation was observed that affected both flows and river temperatures throughout the region. As shown in Table 1-1, without flow augmentation actions, drought conditions in 2014 and 2015 would have resulted in low flows during late summer months in the lower Klamath River, similar to those observed in 2002.

In March of 2013, the PFMC announced its in-river, run-size projection for Klamath River fall Chinook Salmon of 272,000 adults for that year, second only in number to the 2012 projection since recordkeeping began in 1978. Further, based on the prior-year analysis of age components, fisheries experts reported that the 2013 run would have an abnormally high proportion of age four fish, which are typically larger and more accurately modeled (estimated) than younger age classes. Many fishery interests suggested this as a possible indicator that the total bio-mass would be higher than typical. In May, the National Oceanic and Atmospheric Administration (NOAA) California-Nevada River Forecast Center's forecast model indicated that Klamath River flow accretions would be very low in August and September, in fact just 50 percent of the flow rates presented in their 2012 forecast. Tribes, sport-fishing groups, other fish advocates, and fishery resource agencies again formally requested that Reclamation augment flows. Many urged that the 2012 augmentation flow rate (3,200 cfs) be instituted again for the same calendar period.

After reviewing all written materials produced regarding the 2002 die-off and subsequent actions, Reclamation's Northern California Area Office (NCAO) developed two alternative augmentation regimes, to some extent mimicking past (2003-2004) augmentation protocols and designed to use less water from Trinity Reservoir as compared to the 2012 protocol.[5] The alternatives were presented to the TMC during meetings held on June 18 and June 26, 2013, where neither gained broad acceptance. After considerable discussion, a motion was introduced and seconded, recommending that flows be augmented to a rate of 2,800 cfs from August 15 through September 30, complemented by a focused water temperature and fish health monitoring effort. The motion failed, thus the TMC recommendation made in 2012 was, in effect, sustained into 2013. Through further government-to-government consultation and other forums, Reclamation obtained input from the Hoopa Valley Tribe, the Yurok Tribe, the USFWS, National Marine Fisheries Service (NMFS), and other basin partners. The parties discussed 2013 projected fishery conditions and reviewed the Fall Flow Subgroup's 2012 recommendations. Reclamation considered these and a variety of other factors—in addition to seeking responses from water users, power customers, and fishery interests similar to 2012—prior to making a decision on flow augmentation. Key contributing factors were the low Klamath River accretion forecast, along with the Trinity Reservoir storage level being considerably lower than the year prior. Reclamation also considered the potential of the proposed flow augmentation depleting Trinity Reservoir storage levels to the extent that the cold water pool would be reduced, hampering efforts to meet temperature targets in the Trinity River, either in the present or following year. Taking into account this concern, together with an earlier recommendation in a

[5] One alternative would use intermittent pulse flows released from Trinity Reservoir to flush the free-swimming Ich life stage and induce fish migration. The other would involve a more gradual ramp rate on the ascending and descending limbs. Both would emphasize in-season monitoring and quick response adaptive management of flows.

2010 study produced by Dr. Joshua Strange (Strange 2010), Reclamation determined that flows would be augmented to a rate of 2,800 cfs in the lower Klamath River from August 15 through September 21.

NCAO prepared an EA and on August 6, 2013, signed a FONSI for the release of up to 62,000 acre-feet to augment lower Klamath River flows to a rate of 2,800 cfs for preventative purposes. Citing sub-normal Klamath River Basin hydrology, the FONSI stated that augmentation would be provided exclusively from Trinity Reservoir.

Ultimately, as flows (at Klamath, California) during August and September were higher than initially anticipated, 17,500 acre-feet was released for preventative purposes in 2013, and no emergency releases were required. There was no substantial disease outbreak, though it was reported by the Yurok Tribe that several fish died from Columnaris. The post-season run size estimate was 165,100 adults.

NMFS and USFWS co-authored a memorandum dated August 12, 2013 (Joint Memorandum), which included a recommendation for monitoring fish health and conditions in the lower Klamath River along with augmentation flow thresholds (USFWS and NMFS 2013b). The Joint Memorandum included an extensive assessment of historical, biological and hydrologic factors. The key elements of their recommendation for actions to be undertaken, when conditions present a risk of Ich spreading throughout a large number of fish, are summarized below. It must be noted that the recommendations were based on hydrologic, fishery, and other conditions as specifically observed in 2013.

Preventative Flow Augmentation:

- Initiate preventative flow augmentation in the lower Klamath River to a minimum of 2,800 cfs when the cumulative harvest of Chinook Salmon in the Yurok Tribal fishery in the estuary area meets or exceeds 7,000 fish.[6]

- Initiate preventative flow augmentation by August 22 if the fish metric above is not triggered.

- Continue augmentation until September 21, unless the mean daily water temperature in the lower Klamath River is projected to be greater than or equal to 23°C, in which case continue until the daily water temperature is projected to be less than 23°C, or until the end of September when seasonal air temperatures typically cool.

- Implement real-time flow-temperature management using existing water temperature models and NOAA Weather Service weather projections.

- Implement fish pathology monitoring to determine the need for a fish pathology/ mortality emergency release.

[6] The partners' initial reaction to utilizing the fish presence metric to trigger flow augmentation was positive, but some indicated that more time for evaluation of the concept was necessary.

- Monitor conditions to inform need and timing of emergency flow releases based on real-time environmental conditions.

Emergency Flow Augmentation:

- If diagnosis of severe Ich infection of gills (30 or more parasites per gill arch) in 5 percent or greater of a desired sample of 60 adult salmonids, is confirmed by the USFWS Fish Health Center or;

- Observed mortality of greater than 50 dead adult salmonids in a 20 kilometer index reach in 24 hours combined with a confirmed presence of Ich by the USFWS Fish Health Center, then:

  - Immediately double pre-existing flows in the lower Klamath River for a period of 7 days.

In March 2014, the PFMC announced its in-river, run size projection for Klamath River fall Chinook Salmon of 92,800 adults. In May 2014, the NOAA California-Nevada River Forecast Center announced that its forecast model indicated Klamath River flow accretions would be very low in August and September (1,800 – 1,900 cfs or lower), perhaps the lowest for the period of record. On June 20, 2014, the Hoopa Valley Tribe issued a letter to the Secretary of the Interior urging that flows be augmented to a rate of no less than 2,500 cfs beginning in August and continuing through at least September 21, 2014. The Yurok Tribe, PFMC, and other entities later formally requested that Reclamation augment flows. Conversely, Reclamation received letters from CVP water and power users questioning the biological basis for releasing additional water and expressing concern about the impact to water supplies and power generation.

After reviewing the information and consulting with State and Federal fish agencies, tribes, and others, Reclamation announced on July 29, 2014, that it would not provide augmentation flows on a preventative basis, but rather would implement the fish pathology/mortality component of the emergency fall flow release recommendation as described in the 2013 Joint Memorandum.

Accordingly, Reclamation coordinated discussions among fish agencies, tribes, and its own fishery and operations experts to enhance the disease monitoring, reporting, public safety notification, and communication aspects of an emergency response.

During the first half of August 2014, both hydrologic conditions and observed fish health continued to worsen. It was reported that the adult return had begun much earlier than expected, and thousands of fish were stalled at the mouth of Blue Creek on the lower Klamath River mainstem. Other observations indicated fish were exhibiting lethargic behavior—in some cases to the degree that fish could be caught with bare hands. Water temperatures had risen above 23°C, a widely accepted thermal migration barrier mark[7], and water quality was generally poor. A meeting was convened by the Klamath Fish Health Assessment Team (KFHAT) on August 29, 2014, during which they reported that, in their opinion, a significant fish die-off was likely imminent. Attendees at this meeting included the California Department of Fish and Wildlife

[7] A wide array of factors influence fish migration, but it is generally accepted by fishery biologists that a water temperature of approximately 23°C or greater constitutes a thermal barrier to salmonid migration.

(CDFW), the North Coast Regional Water Board, Yurok Tribe, Karuk Tribe, Shasta Valley Resource Conservation District, USFWS, NMFS, Reclamation, and U.S. Forest Service.

After again consulting with fish agencies, Reclamation determined that an emergency release from Trinity Reservoir was necessary to avert a potentially significant fish loss. On August 22, 2014, Reclamation announced it would increase releases from Trinity Reservoir to achieve a flow rate of approximately 2,500 cfs in the lower Klamath River. The ramp-up began the following day, August 23, and the increased release rate continued through September 14, 2014. On September 15, scientists from the Fish Health Center confirmed the presence of Ich parasites on nine of 24 fish taken from the lower Klamath River, six of those sampled with concentrations high enough to constitute a severe infestation in accordance with the Joint Memorandum. Reclamation consulted briefly with Federal scientists before again increasing releases from Lewiston Dam to approximately 3,400 cfs so as to achieve a doubling (from the flow rate of 2,500 cfs maintained earlier to 5,000 cfs) in the lower Klamath River. Per the criteria, the doubling was maintained for one week. Though there were documented reports of severely infected fish present at several locations within the mainstem Klamath River, there was no significant die-off. Formal post-season fishery reviews are not yet available, but anecdotal reports indicated that fish health did not decline following the flow doubling. A total volume amount of 64,000 acre-feet was ultimately released. In addition, approximately 15,500 acre-feet was released from PacifiCorp's Iron Gate Dam from October 4 to October 15, 2014.

The fall-run Chinook Salmon return post-season estimate was 160,000 adults. Reclamation was unable to complete its evaluation of this action under the National Environmental Policy Act (NEPA) as has occurred in past years, because the release was undertaken only after monitoring indicated there was an emergency need for flow augmentation. Due to the emergency nature of the releases, Reclamation consulted with the Council on Environmental Quality (CEQ) regarding alternative arrangements under NEPA as provided for in CEQ regulations.

Conditions in summer and fall 2015 reflected the continuation of drought in the area. Klamath River flows in 2015 were anticipated to be 2,000 cfs in late August, which was consistent with flows observed in 2002, the year of the large fish die-off. Due to the extended drought, there was little to no snow pack, and accretions were predicted to be minimal. Thus, lower Klamath River flows were anticipated to remain low, only getting lower as fall 2015 approached. Because of the 2014 Ich outbreak, it was anticipated that background levels of Ich could contribute to an outbreak in 2015.

The predicted fall run of Chinook Salmon was fairly large, with 119,000 expected to return to the lower Klamath River. While a predicted run of 119,000 was not as high as the fall run of 2002 (170,000), run-size predictions are difficult to make. It is not uncommon for run predictions to be off by 50,000 fish or more in either direction. Furthermore, and perhaps more importantly, in 2015 the USFWS identified "the pattern of upstream migration to be a more important factor in determining disease risk than run size alone" to suggest that run size should be de-emphasized as an indicator for disease risk (USFWS 2015).

Ich was already present in the river system. The Yurok Tribe captured six Chinook Salmon from Blue Creek, a tributary of the lower Klamath River, on July 22, 2015, and all tested positive for Ich infection. One of these fish had a severe infection, with more than 30 Ich spots per gill arch.

This disease occurrence was a month earlier than that discovered in 2014, when it was first observed on August 27. Such high levels of Ich present that early in the year indicated a significant risk for a large fish die-off in 2015. The warmer-than-normal water temperatures, low flows, and presence of Ich already in the system all pointed toward a risk of infection and fish die-off event in 2015.

Reclamation prepared an EA and on August 20, 2015, signed a FONSI for the release of up to 51,000 acre-feet to augment lower Klamath River flows to a rate of 2,800 cfs for preventative purposes. Approximately 48,000 acre-feet was released from Lewiston Dam to improve environmental conditions in the lower Klamath River. Although Ich was detected throughout the monitoring period, no fish die-off occurred. The post-season run size estimate was 83,800 adults (Trinity River Restoration Program 2016).

Hydrologic conditions in summer of 2016 reflected improved conditions, relative to previous years in the area. However, lower Klamath River flows were anticipated to be 2,400 to 2,500 cfs in August and September. Because of this predicted lower-than-median flow level of the lower Klamath River, there was a concern that this level of flow may not be adequate to prevent a disease outbreak. Reclamation prepared a Draft EA and provided it for public review and comment on August 2, 2016. Reclamation signed a FONSI on August 24, 2016, and initiated flow augmentation releases from Lewiston Reservoir on August 25, 2016.

Development of the Draft Long-Term Plan for Protecting Late-Summer Adult Salmon in the Lower Klamath River

In response to the need for augmentation flows in the past several years, the indication that such flows may be needed in future years, and competing environmental and water supply demands for Trinity River Division (TRD) of the CVP water supplies, Reclamation started developing the *Draft Long-Term Plan for Protecting Late Summer Adult Salmon in the Lower Klamath River* (Draft LTP) in 2013. An initial Draft LTP was provided to key stakeholders on December 31, 2014. Reclamation received comments from CDFW, California Water Impact Network, Hoopa Valley Tribe, Klamath Water Users Association, NMFS, San Luis & Delta-Mendota Water Agency and Westlands Water District, Stillwater Sciences, Yurok Tribe and Northern California Power Agency. The Draft LTP was released again to the public on April 17, 2015 (Reclamation 2015a). This Environmental Impact Statement (EIS) further refines the flow augmentation actions, processes, and monitoring that were identified in the Draft LTP.

Purpose and Need

The primary factors currently thought to contribute to infection dynamics and outbreaks of Ich disease in adult salmon returning to the Klamath River are anticipated to continue, including the presence of the Ich pathogen, high water temperatures in the lower Klamath River, low flow conditions in the lower Klamath River, and large run size of fall-run Chinook Salmon. The purpose of the Proposed Action is to reduce the likelihood, and potentially reduce the severity, of any Ich epizootic event that could lead to an associated fish die-off in future years. The need is based on the past extensive fish die-off in 2002, as described above in the *Background and History* section.

Regional Setting

Klamath River Basin

The upper watershed has four main lakes: Crater Lake, Upper Klamath Lake, Clear Lake, and Tule Lake. The lower watershed begins at Iron Gate Dam. Within the Klamath River Basin, the largest communities are Klamath Falls, Oregon, and Yreka, California (DOI and CDFW 2012).

The Klamath River, located in the Klamath River Basin, originates just downstream from Upper Klamath Lake in southern Oregon, and flows 253 miles southwest through northern California to the Pacific Ocean. Along this course, the Klamath River crosses the Cascade Mountains; the Klamath is one of the few rivers to do so. The Klamath River flows through mountainous terrain from the Oregon-California border to the Pacific Ocean. Unlike most river systems, the Klamath River is warmer and flatter in its headwaters, while downstream portions, beginning near Copco Dams 1 and 2, tend to be colder and steeper. The major tributaries entering the mainstem of the Klamath River include Shasta, Scott, Salmon, and Trinity Rivers (see Trinity River Subbasin discussion below), that join the Klamath River below Iron Gate Dam. Downstream from Iron Gate Dam, and for most of its length to the Pacific Ocean, the river maintains a relatively steep, high-energy gradient (National Research Council 2004). The stretch of the Klamath River below the Trinity River confluence is known as the “lower Klamath” (USFWS et al. 2000).

The Karuk Tribe occupies territory along the Klamath River downstream of Iron Gate Dam. A portion of the Hoopa Valley Indian Reservation includes about a quarter mile reach of the Klamath River called Saints Rest Bar upriver from Weitchpec, California (e.g., upriver of the confluence with the Trinity River). The Yurok Tribe Reservation surrounds the lower Klamath River for one mile on either side of the river, stretching roughly from the Pacific Ocean to the confluence with the Trinity River.

Klamath Project

The Secretary of the Interior authorized development of Reclamation’s Klamath Project on May 15, 1905, under provision of the Reclamation Act of 1902 (32 Stat. 388), and construction began in 1906. The Klamath Project consists of three storage facilities and four diversion dams, including the associated canals, drains, pumping plants, two tunnels, and the Lost River Diversion Channel. Storage facilities include Gerber Reservoir on Miller Creek, Clear Lake Reservoir on the Lost River, and Upper Klamath Lake (formed by Link River Dam) at the head of the Klamath River. The Klamath Project provides water to approximately 200,000 to 240,000 acres of agricultural land, with primary crops including onions, potatoes, mint, alfalfa and grass hay, horseradish, and several varieties of cereal grains. Water supplies to the Klamath Project are managed in accordance with the *Biological Opinions on the Effects of Proposed Klamath Project Operations from May 31, 2013 through March 31, 2023, on Five Federally Listed Threatened and Endangered Species,* issued May 31, 2013, by NMFS and USFWS.

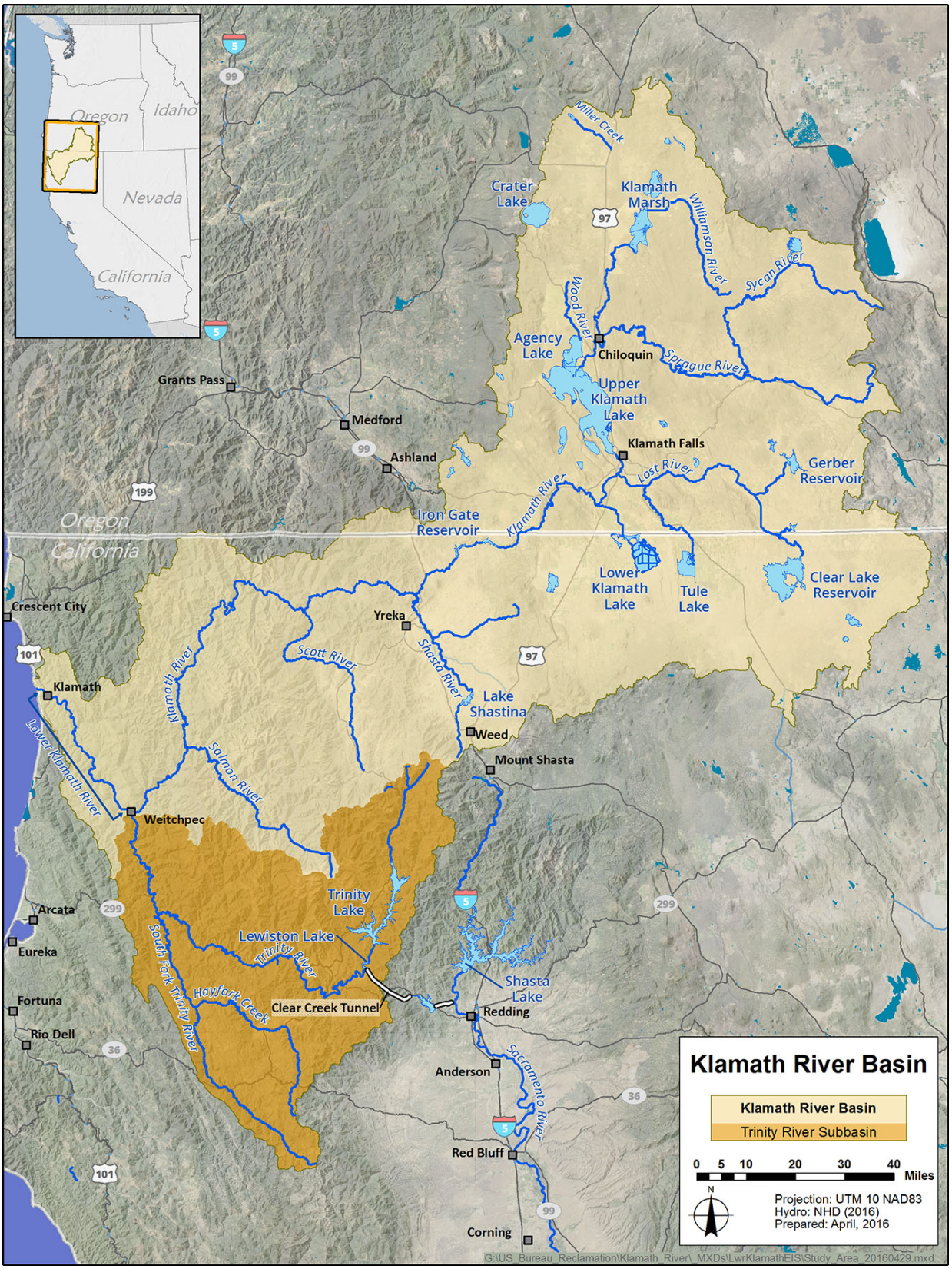

Figure 1-2. Klamath River Basin Including Trinity River Subbasin

PacifiCorp Klamath Hydroelectric Project

Built between 1903 and 1962, PacifiCorp's Klamath Hydroelectric Project consists of seven hydroelectric developments and one non-generating dam. Reclamation owns Link River Dam which PacifiCorp operates in coordination with the company's hydroelectric projects. The Link River Dam, located upstream from PacifiCorp's projects, controls storage within, and releases from, Upper Klamath Lake. Upper Klamath Lake water releases (through Link River Dam) are directed by Reclamation to fulfill the primary objectives of regulating Klamath River flows to benefit fish and wildlife, including providing refuge supplies and meeting irrigation demands. In addition, PacifiCorp manages Upper Klamath Lake for flood control objectives. Diversions for hydroelectric purposes occur after these objectives are attained (PacifiCorp 2016).

On April 6, 2016, the U.S. Department of the Interior (DOI), U.S. Department of Commerce, PacifiCorp, and the States of Oregon and California, signed an agreement that, following a process administered by the Federal Energy Regulatory Commission (FERC), is expected to remove four dams (JC Boyle, Copco 1 and 2, and Iron Gate) on the Klamath River by 2020 (Reclamation 2016). The amended dam removal agreement, which uses existing non-Federal funding and follows the same timeline as the original 2010 Klamath Hydroelectric Settlement Agreement, will be filed with FERC for consideration under their established processes. Under the agreement, dam owner PacifiCorp will transfer its license to operate the Klamath River dams to a private company known as the Klamath River Renewal Corporation. This company will oversee the dam removal in 2020. PacifiCorp will continue to operate the dams until they are decommissioned.

State and Federal officials also signed a separate agreement with irrigation interests and other parties known as the 2016 Klamath Power and Facilities Agreement (KPFA). This agreement is intended to help Klamath Basin irrigators avoid potentially adverse financial and regulatory impacts associated with the return of fish runs to the Upper Klamath Basin, which are anticipated after the dams are removed.

Trinity River Subbasin

The Trinity River Subbasin, part of the Klamath River Basin, originates in the Klamath and Coast Ranges and covers over 2,000 square miles. From its headwaters, the Trinity River flows 172 miles south and west through Trinity County, then north through Humboldt County and the Hoopa Valley and Yurok Indian Reservations. It is the largest tributary to the Klamath River, with their confluence lying at Weitchpec, approximately 44 miles upstream from the mouth of the Klamath River (North Coast Regional Water Quality Control Board 2005). The confluence is just north of the Hoopa Valley Indian Reservation and within the boundary of the adjoining Yurok Indian Reservation.

Trinity River Division Trinity Reservoir is the primary water storage facility in the TRD of the CVP. At capacity, it stores approximately 2.4 million acre-feet (MAF), and receives an average annual inflow of approximately 1.2 MAF. Water released from Trinity Reservoir flows to Lewiston Reservoir, a re-regulating reservoir formed by Lewiston Dam. From Lewiston Reservoir, water can be diverted for use in the Sacramento River Basin via the 10.7-mile Clear Creek Tunnel, or it can pass through Lewiston Dam to flow 112 miles before entering the Klamath River at Weitchpec. The Trinity River Hatchery, located at the base of Lewiston Dam,

also diverts a small quantity of water from Lewiston Reservoir in support of fish hatchery operations (Reclamation 2015b).

Trinity Reservoir storage is used to meet the needs of the cold-water fish resources in the Trinity River and those areas within the Sacramento River Basin, including Clear Creek that is fed from Whiskeytown Reservoir and the Sacramento River.

Water from the Trinity Reservoir, by way of Lewiston Reservoir, is released to the Trinity River year-round as prescribed by the Trinity River Mainstem Fisheries Restoration EIS/ Environmental Impact Report (EIR) Record of Decision (ROD), as part of the requirements of the TRRP (DOI and Hoopa Valley Tribe 2000).

Central Valley Project Facilities and Service Areas

The CVP is composed of 20 reservoirs with a combined storage capacity that exceeds 11 MAF, more than 10 hydroelectric power plants, and more than 500 miles of major canals and aqueducts. The major on-stream CVP reservoirs in the Central Valley include Shasta Lake on the Sacramento River, Folsom Lake on the American River, New Melones Reservoir on the Stanislaus River, and Millerton Lake on the San Joaquin River. As described in Chapter 4, "Surface Water Supply and Management," the action alternatives will have no impact on Friant or New Melones Reservoir operations or San Joaquin River flows. Therefore, Friant and New Melones Reservoirs, and downstream rivers' segments above the Sacramento-San Joaquin River Delta (Delta), are not included in the study area for this EIS.

As described above, the CVP also diverts water from Trinity Lake via Lewiston Reservoir (on the Trinity River) to the Sacramento River system (see Figure 1-3). CVP pumping plants and canals include the Red Bluff Pumping Plant, which diverts water from the Sacramento River into the CVP Tehama-Colusa Canal; Folsom South Canal, which conveys water from Folsom Lake to southeastern Sacramento County; Contra Costa Canal Pumping Plant, which diverts water from Rock Slough in the Delta into the CVP Contra Costa Canal; and C.W. Jones Pumping Plant, which diverts water from the south Delta into the CVP Delta-Mendota Canal (Reclamation 2015c).

The CVP and State Water Project (SWP) operate in a coordinated manner in accordance with Public Law (PL) 99-546 (October 27, 1986), directing the Secretary of the Interior to execute the Coordinated Operations Agreement (COA) and State Water Resources Control Board decisions and water rights orders related to the CVP's and SWP's water rights permits and licenses to appropriate water by diverting to storage, by directly diverting to use, or by re-diverting releases from storage later in the year or in subsequent years.

Managed by the California Department of Water Resources (DWR), the SWP is the largest state-owned, multi-purpose, water storage and delivery system in the United States. The multi-purpose SWP facilities deliver water through contracts between DWR and 29 public water agencies throughout California.

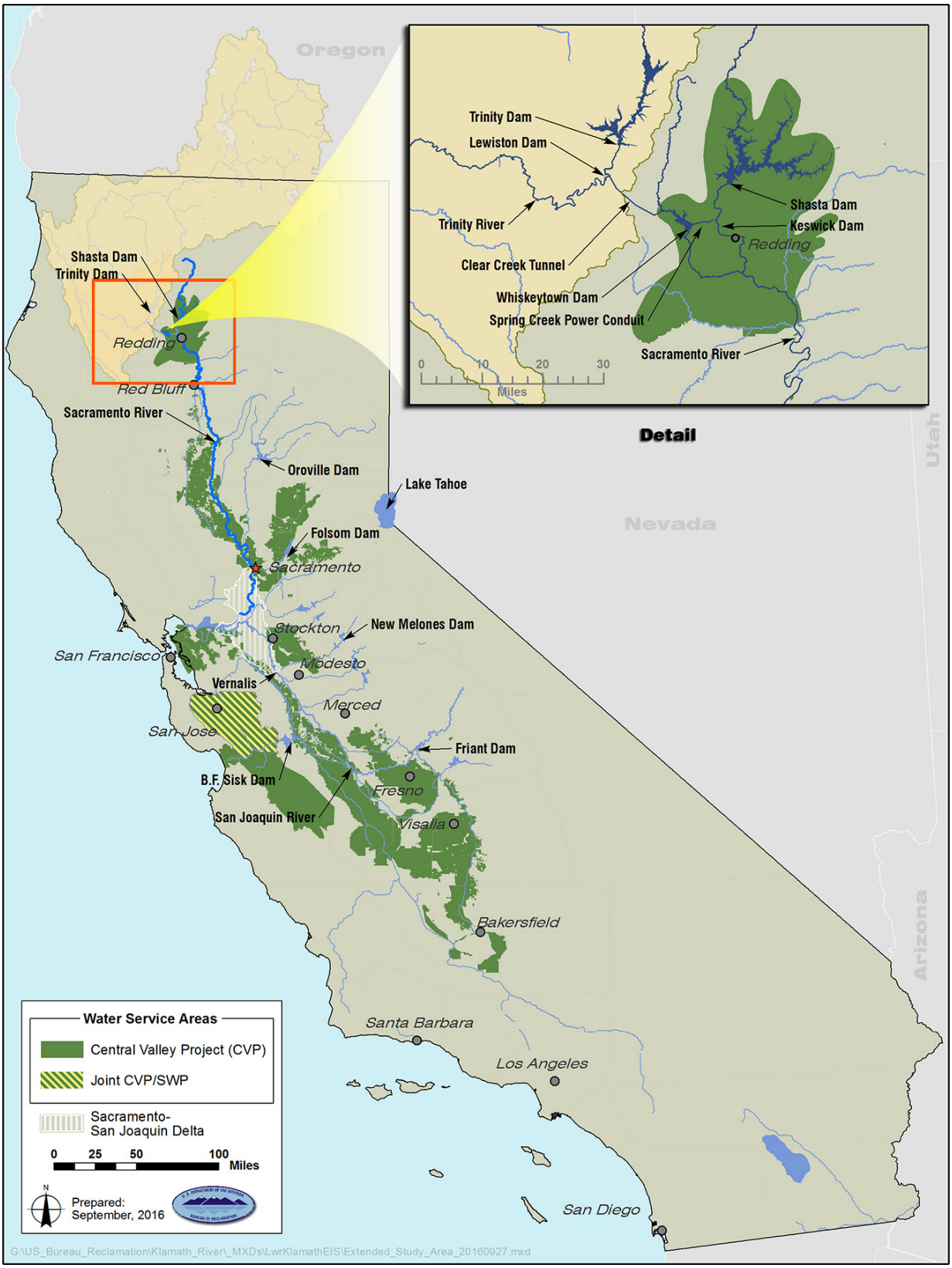

Figure 1-3. CVP Facilities and Water Service Areas

Sacramento River Basin

The Sacramento River is the largest river and watershed system in California. This 27,000–square mile basin drains the eastern slopes of the Coast Range, Mount Shasta, the western slopes of the southernmost region of the Cascades, and the northern portion of the Sierra Nevada. The Sacramento, McCloud and Pit Rivers flow into Lake Shasta, a 4.5 MAF reservoir formed by Shasta Dam. From this dam, the Sacramento River winds approximately 30 miles south through the foothills between Redding and Red Bluff. Many small and moderate-sized tributaries join the river, from both east and west, including Clear, Cottonwood, Cow, and Battle Creeks. At Red Bluff, a large portion of its flow is diverted into canals delivering irrigation water to agriculture south in the Sacramento Valley. The Sacramento River is joined by its largest tributary, the Feather River, at Verona. About 10 miles downstream, the Sacramento River flows through the City of Sacramento and receives the American River, its second largest tributary. The mouth of the Sacramento River is at Suisun Bay near Antioch, where it combines with the San Joaquin River. The Sacramento River, now nearly a mile wide at its mouth, flows into San Francisco Bay and joins the Pacific Ocean under the Golden Gate Bridge in San Francisco (Sacramento River Watershed Program 2016).

Delta

The Delta is formed by the confluence of the Sacramento and San Joaquin Rivers, and is composed of an extensive tidally-influenced network of interconnecting channels surrounding Delta islands or bordering adjacent uplands. The specifically defined “Legal Delta” covers 738,000 acres, of which about 8.3 percent is water. Much of the land is located in islands or tracts that sit below sea level, and are collectively protected by over a thousand miles of levees. Channel flow in the Delta is influenced by inflow from upstream rivers, tidal flows, diversion for in-Delta uses, and exports at the CVP and SWP facilities. Water quality is influenced by upstream water development, including reservoir storage, flood control, diversion and water transfers; return flows from upstream and in-Delta agriculture and municipal and industrial wastewater releases. The Delta is often referred to as the upper estuary associated with the San Francisco Bay, and is connected through the San Pablo Bay, Carquinez Straits, and Suisun and Honker Bays. The western edge of the Delta is about 53 miles from the Golden Gate Bridge. The Delta also serves as a key resource for water management activities in the state (Reclamation 2009).

As described in Chapter 2, “Description of Alternatives,” augmentation flows under the action alternatives are released from Lewiston Dam, and affect resources in and along the Trinity River and lower Klamath River. Accordingly, within the Klamath River Basin, the study area for most resource areas focuses on TRD facilities, in and along the Trinity River downstream of Lewiston Reservoir, and in and along the Klamath River downstream from the confluence with the Trinity River (i.e., lower Klamath River). In addition, due to exports from the TRD to the Sacramento River Basin, the study area for most resource areas also includes CVP facilities, in and along rivers and waterways downstream from CVP facilities (including the Delta), and CVP service areas. Due to the coordinated operation with the SWP, the study area for most resource areas also includes SWP facilities (i.e., Oroville Dam and Reservoir), and in and along rivers and waterways downstream from SWP facilities (i.e., Feather River). For analysis purposes for most resource areas, the study area was divided into two regions, the Lower Klamath and Trinity River Region, and the Central Valley and Bay-Delta Region.

Statutory Authority

The Trinity River Division Central Valley Project Act of 1955 (PL84-386) provides the principal authorization for implementing the action alternatives. Specifically, Section 2 of the 1955 Act limits the integration of the TRD with the rest of the CVP and gives precedence to in-basin needs including that "the Secretary is authorized and directed to adopt appropriate measures to insure preservation and propagation of fish and wildlife…" (Proviso 1) and "that not less than 50,000 acre-feet shall be released annually from the Trinity Reservoir and made available to Humboldt County and downstream users." (Proviso 2)[8] The following are also authorities for the Proposed Action: the Trinity River Basin Fish & Wildlife Management Act of 1984 (Act of October 24, 1984 (PL 98-541); as amended by the Act of October 2, 1992 (PL 102-377); Act of November 13, 1995 (PL 104-46); Act of May 15, 1996 (PL 104-143)) (that directs the Secretary to restore the fish populations impacted by the TRD facilities); the Fish and Wildlife Coordination Act (FWCA) (16 USC 661) and section 3406(b)(1) of the Central Valley Project Improvement Act (CVPIA). In addition, the Proposed Action is also consistent with Reclamation's obligation to preserve tribal trust resources. Additional information on these statutory authorities is provided in the Statutory Authority Appendix.

Study Period of Analysis

In 2008 and 2009 the USFWS and NMFS, respectively, issued biological opinions (BOs) for the Coordinated Long-Term Operation of the CVP and SWP (USFWS 2008, NMFS 2009). In these BOs, Reclamation analyzed its operations through the year 2030. Because the TRD is a component of the CVP, and Reclamation would need to revisit effects to Federal Endangered Species Act (ESA) listed species from operation of the CVP in 2030, Reclamation has chosen to analyze effects from the proposed action through the same time period, to be consistent with its BOs to operate the CVP.

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[8] For the actions implemented in 2012, 2013 and 2014, Reclamation relied primarily on the provision in Section 2 of the Trinity River Division Authorization 1955 Act that authorizes and directs the Secretary to insure "the preservation and propagation of fish and wildlife" downstream of the TRD facilities. On October 1, 2014, the U.S. District Court for the Eastern District of California found that this provision of Section 2 of the 1955 Act did not provide authority for the 2013 augmentation releases. A notice of appeal has been filed regarding this decision. In 2015, Reclamation added an explanation concerning the use of Proviso 2 of the 1955 Act, in addition to Proviso 1.

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Chapter 2
Description of Alternatives

Alternatives Development and Screening

The U.S. Department of the Interior, Bureau of Reclamation (Reclamation) developed the Proposed Action to meet the Purpose and Need, while including input received during preparation of the *Draft Long-Term Plan for Protecting Late Summer Adult Salmon in the Lower Klamath River* (Draft LTP) (Reclamation 2015a) and input received during the public scoping process (Reclamation 2015b). In determining alternatives to the Proposed Action, Reclamation developed four criteria to effectively address the Purpose and Need statement to screen potential alternatives:

- **Effective:** Addresses more than one of the significant contributing factors to *Ichthyophthirius multifiliis* (Ich) epizootic events: (1) crowded holding conditions for pre-spawn adults, (2) warm water temperatures, and (3) presence of disease pathogens.

- **Substantial Risk Reduction:** Capability of meaningfully and substantially reducing the likelihood, and potentially reducing the severity of any Ich epizootic event that could lead to an associated fish die-off.

- **Immediate Implementability:** Actions may be needed as early as August 2017, therefore alternatives need to be able to be implemented immediately. Further, the term proposed for this Environmental Impact Statement (EIS) is 2017 through 2030. This period is relatively short, and measures need to be able to provide measurable benefit within this time period.

- **Consistent with Laws and Regulations:** Consistent with Federal Reclamation law; other Federal laws; State of California and Oregon laws, water rights, permits, and licenses.

Reclamation also considered the environmental effects of potential alternatives in the development and screening of alternatives.

Alternatives Retained for Detailed Analysis

No Action Alternative

The No Action Alternative represents future conditions without implementation of the proposed action, and the resulting environmental effects from taking no action. Under the No Action Alternative, Reclamation would not implement flow augmentation actions to supplement flows in the lower Klamath River.

The No Action Alternative assumes continued implementation of existing projects, plans, ecosystem restoration projects (e.g., Trinity River Restoration Program), land or resource management plans, water supply management and wastewater facilities, flood management facilities, and recreational facilities. The No Action Alternative assumes future conditions such as climate change and sea-level rise, development of lands in accordance with general plans in areas served by Central Valley Project (CVP) water supplies, and continued operation of the CVP to the year 2030.

Concerning the PacifiCorp Hydroelectric facilities, the U.S. Department of the Interior (DOI), U.S. Department of Commerce, PacifiCorp, and the States of Oregon and California, signed an agreement that, following a process administered by Federal Energy Regulatory Commission (FERC), to remove four dams (JC Boyle, Copco No. 1 and Copco No. 2, and Iron Gate) on the Klamath River. The amended dam removal agreement, which uses existing non-Federal funding, and follows the same timeline as the original 2010 Klamath Hydroelectric Settlement Agreement, will be filed with FERC for consideration under their established processes. Under the agreement, dam owner PacifiCorp will transfer its license to operate the Klamath River dams to a private company known as the Klamath River Renewal Corporation (KRRC). The KRRC will oversee the dam removal work.

The Klamath Facilities Removal Final EIS/Environmental Impact Report (EIR) was completed in 2012 (DOI and DFG 2012); however, a Record of Decision (ROD) for the dam removal was not issued. On June 16, 2016, FERC approved a temporary suspension of the relicensing process in order for PacifiCorp and the KRRC to develop two additional applications for FERC review, including an application to transfer the four dams/facilities to the KRRC; and an application by the KRRC to surrender and remove the four dams. As these applications are pending, FERC has not approved the removal of the four dams. Therefore, for the purposes of this EIS, the No Action Alternative includes PacifiCorp operating under the current annual license with the dams remaining in place. The California Department of Fish and Wildlife (CDFW), funded by PacifiCorp, would continue to operate the Iron Gate Hatchery under its current operations. Flows downstream of Iron Gate Dam would remain similar to current flows, which are released consistent with the 2013 Klamath Biological Opinion (BO) for Reclamation's Klamath Project.

Proposed Action (Alternative 1)

The Proposed Action (Alternative 1) includes supplemental flows from Lewiston Dam to prevent a disease outbreak in the lower Klamath River in years when the flow in the lower Klamath River is projected to be less than 2,800 cubic feet per second (cfs). The water for these supplemental flows would come from water stored in Trinity Reservoir, to support "appropriate measures for the preservation and propagation of fish and wildlife" (Proviso 1) and releases of "not less than 50,000 acre-feet" for Humboldt County and downstream water users (Proviso 2), as provided in the 1955 Trinity River Division Act.

Flow Augmentation Components

The Proposed Action is comprised of three different flow augmentation components to be implemented as needed in a phased approach, based on environmental (e.g., flow) and biological conditions. The three components include: (1) a preventive base-flow release that targets increasing the base flow of the lower Klamath River to 2,800 cfs from mid-August to late September, to improve environmental conditions; (2) a preventive pulse flow to be used as a

secondary measure to alleviate continued poor environmental conditions and signs of Ich infection in the lower Klamath River; and (3) a contingency volume, to be used on an emergency basis as a tertiary treatment to avoid a significant die-off of adult salmon when the first two components of the Proposed Action are not successful at meeting their intended objectives. Reclamation would implement these flow augmentation components in coordination with Federal, State, and tribal resource specialists, including fisheries biologists or pathologists (i.e., Long-Term Plan to Protect Adult Salmon in the Lower Klamath River [LTP] Technical Team).

Details of implementing each flow component of the Proposed Action (Alternative 1) are described below.

Preventive Base Flow Augmentation Initiate preventive base-flow augmentation from Lewiston Dam when one or more of the following conditions occur:

- Flow in the lower Klamath River is projected to be less than 2,800 cfs at the Klamath, California gage (gage # 11530500) in August and September (USFWS 2015).
- Ich infection of adult salmon or steelhead is identified in July and early August, suggesting a low-level infection is present that could worsen with poor environmental conditions.
- Thermal regime of the lower Klamath River is inhibitory to the upstream migration of infected adult salmon.
- High densities of adult fall-run Chinook Salmon and steelhead are holding in the lower Klamath River.

In coordination with the LTP Technical Team, Reclamation will initiate preventive base-flow augmentation releases by August 22 to meet the target flow (2,800 cfs) in the lower Klamath River, if the fish harvest metric above is not met. This date was selected based on historical harvest information for the estuary and the middle Klamath River area (as summarized in USFWS and NMFS 2013). Reclamation will continue flow augmentation to target a flow of 2,800 cfs in the lower Klamath River, as measured at the Klamath, California gage through September 21. The LTP Technical Team would continue to implement fish-pathology monitoring to determine the potential need for the secondary flow augmentation action (Preventive Pulse Flow).

Preventive Pulse Flow During the preventive base flow period, a preventive pulse flow targeting a rate of 5,000 cfs for one 24-hour period at the Klamath, California gage would occur when the peak fall-run migration (typically the first or second week of September) is identified in the lower Klamath River, as indicated by fish density. This flow level, based on 2015 experience, intends to use a small volume of water to provide a change to the environmental conditions of the lower Klamath River; further reducing the Ich infection risk that could result in a disease outbreak (Reclamation 2015c). Specifically, the anticipated benefit of the pulse flow is to enhance flushing and dilution of parasites in the river when the bulk of fall-run Chinook Salmon adults are likely to be in the lower river; while also improving water quality/quantity to facilitate movement of adult salmon, eliminating the potential for crowding. Conditional release

of this pulse flow requires low-level infections of Ich (less than 30 Ich per gill arch), confirmed on three fall-run adult salmon (of a maximum sample size of 60 fish), captured in the lower Klamath River in one day during this time of typical peak migration, subject to LTP Technical Team review. Disease sampling and confirmation of disease findings would follow the methods as described by the U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) in the 2013 Fall Flow Release Recommendation (2013).

Emergency Pulse Flow Augmentation Initiate an emergency flow release to target a flow of 5,000 cfs in the lower Klamath River for up to five days in August or September, if these emergency conditions exist as identified by USFWS and NMFS (2013):

- Diagnosis of severe Ich infection of gills (30 or more parasites on a gill arch) in 5 percent, or greater, of a desired sample of 60 adult salmonids confirmed by the USFWS' California-Nevada (CA-NV) Fish Health Center, or

- Observed mortality of greater than 50 dead adult salmonids in a 20 kilometer reach in 24 hours, coupled with the confirmed presence of Ich by the USFWS CA-NV Fish Health Center.

The protocol for sharing and confirming information would be used on a real-time basis to determine if and when the emergency flows would be implemented. The LTP Technical Team and agency managers would be on high alert during the flow augmentation action and would be getting timely on-the-ground monitoring results. The USFWS CA-NV Fish Health Center would provide a pathology report documenting the findings of its diagnostics survey to Federal, State, and tribal fish biologists and pathologists, and the Klamath Fish Health Assessment Team (KFHAT). An emergency release would be considered by Reclamation on receipt of a positive pathology report.

The need for emergency flow augmentation is expected to be low considering its infrequent use in the past (only once in 6 years of implementing an action since 2002), and the knowledge gained from previous years regarding the dynamics of Ich infection and environmental variables including flow. Since the 2002 fish die-off, additional emergency releases were only required during 2014 when preventive base flows were 2,500 cfs (i.e., 300 cfs lower than the Proposed Action) in the lower Klamath River. Accordingly, the Proposed Action (Alternative 1) was developed to minimize, to the extent possible, the use of these emergency flows.

Annual Implementation Process

The annual implementation process, beginning in late March, outlines a month-by-month process to determine: whether augmentation flows are required in a given year; which water source(s) would be used for augmentation flows; and, to finalize and implement augmentation flows. Table 2-1 presents the process by month that Reclamation would follow.

Table 2-1. Annual Implementation Schedule for the Proposed Action (Alternative 1)

Timeframe	Actions
March through May	1. Reclamation obtains Klamath Basin accretion forecasts from the NOAA California Nevada River Forecast Center 2. Reclamation develops projections for lower Klamath River flows through September, based on: the NOAA accretion forecast; 2013 USFWS and NMFS Klamath Project Biological Opinion release requirements from Iron Gate Dam; tribal boat dance flows (even years in the Klamath River, and odd years in the Trinity River); and the Trinity River ROD flows from Lewiston Dam 3. Reclamation assesses environmental conditions and the applicability of augmentation criteria in collaboration with tribes and resource agencies 4. Reclamation assesses hydrologic conditions (current and projected) and water supply allocations in the CVP 5. Reclamation coordinates with the USFWS, CDFW and NMFS
May through July	1. Reclamation collaborates with tribes, CVP water and power users, regulatory agencies, and other key stakeholders for additional input 2. The LTP Technical Team continues to assess environmental conditions and the need for augmentation flows 3. Reclamation refines the augmentation flow regime, if applicable 4. Reclamation coordinates with Humboldt County on potential use of their Contractual Right for preventive and emergency flow actions
August through September	1. Preventive flow augmentation is implemented, if needed 2. The LTP Technical Team conducts monitoring, evaluates data and conditions, and determines the need for supplemental actions; including preventive pulse flow and emergency pulse flow augmentation
October through December	1. The LTP Technical Team convenes to review and document outcomes from the year's activities

Note:
The LTP Technical Team would consist of Federal, State, and tribal resource specialists, including fisheries biologists or pathologists.
Key:
CDFW = California Department of Fish and Wildlife
CVP = Central Valley Project
NMFS = National Marine Fisheries Service
NOAA = National Oceanic and Atmospheric Administration
Reclamation = U.S. Department of the Interior, Bureau of Reclamation
ROD = Record of Decision
LTP = Long-Term Plan to Protect Adult Salmon in the Lower Klamath River
USFWS= U.S. Fish and Wildlife Service

Monitoring and Research

Monitoring and research efforts will include both essential monitoring actions (e.g., monitoring required to measure the flow augmentation component triggers, such as Ich infestation level) as well as additional monitoring and research actions, to inform potential refinement of flow augmentation trigger criteria.

Essential Monitoring Actions The following required essential monitoring actions evaluate if the specific criteria have been triggered for the three flow augmentation components. These essential monitoring actions would be performed annually.

Flow and Water Temperature Real-time flow and water temperature data would be obtained from existing U.S. Geological Survey (USGS) stream gages along the Klamath and Trinity Rivers. Preventive and emergency flow augmentation criteria and actions are based upon the Klamath, California gage (gage # 11530500).

Fish Density, Including Estuary Counts The Yurok Tribe would collect harvest and catch effort data for the estuary. Estimates of fall-run Chinook Salmon adult abundance in the estuary will be made based on weekly or more frequent harvest quantity data and the fishing efforts of the Yurok Tribe. A key assumption is that the number of Chinook Salmon that escape estuary harvest is positively associated with the number of fish that are harvested. In addition, other methods for determining fish densities will be developed through the research and monitoring actions, such as in-river sonar.

Fish Health Monitoring (Ich) Monitoring and assessment of salmon and steelhead for the presence of Ich would be conducted along the lower Klamath River during the late-summer and fall months (July through October) by the Yurok, Hoopa and Karuk Tribes, or resource agencies. Fish will be collected using gill nets, dip nets, spears, and hook-and-line. During monitoring activities, the first gill arch on each side of the fish will be removed and examined in the field for Ich with a dissecting microscope, and slides will be prepared for archiving. Samples will be provided to the USFWS CA-NV Fish Health Center for examination with more powerful microscopes. Individual Ich organisms on the gill arches would be counted as soon as possible. Additional information, including fish length and potential presence of a coded-wire tag will be recorded. If the fish is missing its adipose fin (indicative of coded-wire tagging), the head will be collected and frozen for later retrieval of the coded-wire tag. All results would be presented to the LTP Technical Team and KFHAT.

For emergency flow augmentation criteria related to observed mortality, Reclamation will utilize information from KFHAT and other sources, as available. The KFHAT requests that public individuals provide notification if large numbers of dead or dying fish are observed in the lower Klamath River. This information, in conjunction with observations made by the Yurok and Karuk Tribes during their fish health monitoring, and by the USFWS and CDFW, would be utilized for identifying the emergency flow augmentation trigger of 50 or more freshly dead salmon in a 20 kilometer (12.43 mile) reach.

Potential Additional Monitoring and Research Actions and Flow Component Trigger Criteria Refinement As part of the Proposed Action (Alternative 1), additional monitoring and research actions would be conducted to further scientific understanding of causative factors of Ich infection and outbreak in the lower Klamath River. Based on the concept of adaptive management, and utilizing additional scientific information on the causative factors, Reclamation may refine trigger criteria of the three flow components (e.g., preventive base flow augmentation, preventive pulse flows, and emergency pulse flow augmentation) to further reduce the likelihood—and potentially the severity—of any Ich epizootic event. The process for potential refinement of flow component trigger criteria will be based on adaptive management principles, as follows:

- Develop hypotheses and conceptual models to identify potential causative factors (e.g., identification of relationships between salmon and environmental conditions—including pathogens—to ecological processes and potential management actions).

- Develop and refine performance measures related to reducing the likelihood of Ich epizootic events and associated fish die-offs.

- Collect and evaluate relevant data and other information pertaining to physical and biotic components of the Klamath River system, salmon performance, pathogen presence, and Ich infestation.

- Propose modifications to flow augmentation trigger criteria that would decrease the likelihood—and potentially the severity—of Ich epizootic outbreaks.

- Recommend implementation of additional monitoring and research programs to examine how selected management actions meet performance measures.

Table 2-2 identifies additional monitoring and forecasting actions that may be conducted as part of the Proposed Action to inform refinement of flow augmentation trigger criteria. Table 2-3 identifies potential key scientific questions and related research and monitoring efforts to support hypothesis and conceptual model development. It is recognized that the identified actions in Tables 2-2 and 2-3 are not all-inclusive. Reclamation anticipates that new developments or studies may be identified and conducted that could influence future monitoring and research efforts.

This monitoring process would be administered by Reclamation with input from the LTP Technical Team. Participants would typically convene several times a year; including late-fall, to review outcomes from the previous year's activities; and spring to make recommendations concerning the coming year's preventive base flow augmentation, preventive pulse flow and emergency flow augmentation actions, and related monitoring. Refinement of the trigger criteria for the flow components could result in minor modifications to preventive base flow augmentation, preventive pulse flow, and emergency flow augmentation actions described in this EIS.

The purpose of adaptive management is to allow for mid-course corrections that can be employed to better manage flow as new information becomes available. For example, the flow target of 2,800 cfs could be modified through an adaptive management approach, as could the frequency of flow augmentation actions. While it is likely that adjustments in flow may lead to using less water as causative factors become better understood, it is also possible that additional flow may be necessary. Reclamation would prepare supplemental environmental documentation, as necessary, as changes to the flow augmentation actions are contemplated based on new information gained through adaptive management.

Table 2-2. Potential Additional Monitoring and Forecasting Actions to Inform Flow Augmentation Trigger Criteria for Alternatives 1 and 2

Monitoring/Forecasting Actions	Data Type
Adult Salmon Abundance in Estuary/Lower Klamath River	
Yurok Tribal fishery landings	- Index of abundance/density
CDFW sport creel census	- Index of abundance/density
Summer snorkel surveys at thermal refugia	- Index of density
CDFW upriver weir counts	- Index of ultimate abundance
PSMFC pre-season run-size projections	- Index of abundance planning
Migration run timing in river and at hatchery	- Index of run composition and response to flow augmentation
Willow Creek weir counts (late August, removed at 2400 cfs)	- Index of run composition and response to flow augmentation
Karuk Tribal fishery and health monitoring/mouth of salmon	- Index of run composition and response to flow augmentation - Index of infectivity
Adult Salmon Pathology	
Adult salmon samples (lower Klamath River)	- Index of infectivity
External parasite/bacterial examination	- Index of infectivity
USFWS histology/pathology	- Index of infectivity/pathogenicity
Mortality/pre-spawning mortality	- Index of pathogenicity
Hatchery sampling	- Index of infectivity
Water Temperature and Flow	
USGS Gage No. 11530500	- River discharge
Yurok Tribe Environmental Program monitoring	- Water temperature
Annual hydrologic February – April forecasts	- Planning – river discharge
River water temperature forecasting models	- Planning – water temperature
Meteorology forecasting	- Planning – water temperature and river discharge

Key:
CDFW = California Department of Fish and Wildlife
PSMFC = Pacific States Marine Fisheries Commission
USFWS = U.S. Fish and Wildlife Service
USGS = U.S. Geological Service

Table 2-3. Potential Scientific Questions and Research and Monitoring Efforts to Support Hypothesis and Conceptual Model Development for Alternatives 1 and 2

Scientific Questions	Research and Monitoring Efforts
How well do Yurok Tribal fishery metrics and other fish density estimates reflect salmon abundance and densities in the lower Klamath River?	- Net harvest index of immigrating salmon abundance - Extent and persistence of thermal refugia use - Underwater observations of atypical salmon behaviors - Migration/movement responses to flow and temperature cues - Fishery independent measures of abundance - Test ARIS camera technology for measuring salmon abundance and densities - Efficacy of flow augmentation criteria for protecting late-running spring Chinook Salmon
What are the key dynamics and metrics for determining Ich (and other pathogens) infectivity and pathogenicity?	- Ich infectivity and relationships to adult salmon spatiotemporal dynamics - Triggers for Ich infectivity and pathogenicity - Relationship of Ich infectivity to gill hyperplasia and pathogenicity - Spatiotemporal and interannual dynamics of Ich infection - "Hangover Effect" (e.g., latent carry-over of pathogens to successive years) - Synergism of Ich infectivity with other pathogens (i.e., Columnaris) - Interaction of resident fish as a reservoir of Ich - Synergism of Ich infectivity with other stressors (water quality, microcystin) - Sentinel fish monitoring for presence or virulence of pathogens - Identification of controlling factors and thresholds for Ich infectivity
What potential techniques are available, and can effective monitoring and assessment techniques for Ich be used as part of annual management?	- Non-lethal histologic sampling techniques - Controlled experiments on Ich-infected adult salmon - Infective-stage parasite (theront) density in water samples - eDNA techniques to measure Ich presence and density - Use of sentinel fish histopathology monitoring - ARIS technology - Evaluate pathogenicity of different genotypes of Ich/genotype(s) in Klamath River
How have hatchery operations and in-river harvest affected run timing, and does current management accommodate or provide for manipulation of run-timing?	- Has selection of run-timing been significant in Klamath Basin stocks? - Would manipulation of broodstock selection be of value to reduce vulnerability?
How much influence does upstream reservoir management/operation have on lower Klamath River water temperatures?	- Water temperature monitoring at key measurement nodes - Improve/update calibration of water temperature models
What are the potential inadvertent or unanticipated adverse effects of late-summer flow augmentation that may require monitoring and mitigation?	- Asynchronous cue attracting a pre-mature entry of fall run from ocean - Effects to resident fish, herpetofauna, and invertebrates, especially in upstream reaches - Advance immigration of fall run to upper Trinity River increasing potential of spawning overlap with spring run - Depending on source of late-summer flow, impair or delay immigration of spring run (i.e., reduction in spring Trinity River ROD releases) - Impacts to Hoopa Tribal fishery (net-fouling) - Impacts to hatchery operations by prematurely queuing immigration/arrival - Impacts to thermal refugia
What are salmon responses to late-summer flow augmentation?	- Employ field and analytic techniques to monitor and measure salmon response to flow and temperature management - Migration initiation, rates, and behavioral responses - Flow, temperature relationships with infectivity and pathogenicity of Ich

Key:
ARIS = Adaptive Resolution Imaging Sonar
ROD = Record of Decision
eDNA = Environmental DNA

Trinity River Record of Decision Flow Rescheduling Alternative (Alternative 2)

The Trinity River ROD provides for annual instream flows below Lewiston Dam according to the recommendations provided in the Trinity River Mainstem Fishery Restoration Final EIS/EIR (DOI and Hoopa Valley Tribe 2000; USFWS et al. 2000). Under the Trinity River ROD, the total volume of water released from the Trinity River Division (TRD) to the Trinity River will range from approximately 369,000 acre-feet to 815,000 acre-feet, depending on the annual hydrology (water-year type) determined as of April 1 of each year. For the Trinity River mainstem, the recommended flow regimes link two essential purposes deemed necessary to restore and maintain the Trinity River's fishery resources: 1) flows to provide physical fish habitat (i.e., appropriate depths and velocities, and suitable temperature regimes for anadromous salmonids), and 2) flows to restore the riverine processes that create and maintain the structural integrity and spatial complexity of the fish habitats.

The Trinity River ROD Flow Rescheduling Alternative (Alternative 2) includes supplemental flows from Lewiston Dam to prevent a disease outbreak in the lower Klamath River in years when the river's flow is projected to be less than 2,800 cfs. Supplemental flows would come sequentially from water stored in Trinity Reservoir, primarily through modifying the pattern of releases (i.e., rescheduling) for Trinity River ROD flows. If rescheduling of ROD flows is insufficient to meet flow augmentation requirements, water would be released pursuant to authorities provided in the 1955 Trinity River Division Act, including Provisos 1 and 2. The supplemental flows would be comprised of the same three components described for the Proposed Action (Alternative 1), including preventive base flow augmentation, preventive pulse flow, and emergency pulse flow augmentation.

Under Alternative 2, Trinity River ROD flow releases would be reduced in earlier months to reserve a portion of the total release volume, to meet the estimated need for supplemental flows later in the season. Table 2-4 identifies the volume of water, based on Trinity River ROD year type, to be rescheduled for release in August and September for flow augmentation. Figure 2-1 shows how the pattern of Trinity River ROD flows would be rescheduled during each year type, by reducing the flows early in the year to provide a reserve for release in August and September for flow augmentation. For extremely wet, wet, normal, and dry year types, the ramping rate would be accelerated following the peak spring flows (e.g., rate of flow curtailment on falling limb would be accelerated). For these four year types, the duration of spring peak flows and the magnitude of the spring peak flows would be maintained. For critically dry years, the duration of the peak spring flows would be reduced as shown in Figure 2-1. For critically dry years, the magnitude of the spring peak flows and ramping rates would be maintained. The Trinity Management Council will continue to guide the Adaptive Environmental Assessment and Management Program and will recommend possible adjustments to the annual flow schedule (within the designated flow volumes provided in Table 2-4) to ensure that the restoration and maintenance of the Trinity River anadromous fishery continues, based on the best available scientific information and analysis.

Table 2-4. Trinity River ROD Flow Volumes by Water Year Type

Water Year Classification	Total Trinity Reservoir Inflow for Water Year Classification[1] (acre-feet)	Total Volume of Trinity River ROD Flows[1] (acre-feet)	Volume Rescheduled for Alternative 2[2] (acre-feet)
Extremely Wet	>=2,000,000	815,000	3,228
Wet	1,350,000-1,999,999	701,000	7,593
Normal	1,025,000-1,349,999	647,000	10,536
Dry	650,000-1,024,999	453,000	23,476
Critically Dry	<650,000	369,000	33,261

Notes:
[1] As described in the Final Trinity Mainstem Fishery Restoration Environmental Impact Statement/Report (USFWS et al. 2000)
[2] Volumes reflect average estimated preventive base flow augmentation by year type based upon CalSim inputs
Key:
ROD = Record of Decision

The annual implementation schedule for Alternative 2 would be the same as described for the Proposed Action (Alternative 1). Monitoring and research actions would be the same as those described for the Proposed Action (Alternative 1).

Alternatives Eliminated from Detailed Evaluation

During the alternatives development and screening process, a number of project alternatives were considered but eliminated from further consideration. These alternatives and the rationale for their removal from further consideration are described briefly below.

Structural Flow Augmentation Measures

Several alternatives were identified to provide additional flow, or improve the quality of flow, through construction of various facilities. These included construction of water treatment facilities for augmentation flow sources, additional or new storage in the Klamath River basin, or additional storage in the Trinity River basin. These alternatives included such elements as: constructing desalination plants for ocean water, and associated pipelines and storage facilities; constructing water treatments plants above the confluence of the Trinity River, and associated storage facilities; constructing new or expanded storage in the Klamath River basin (including dams and reservoirs on the Shasta and Scott Rivers); and, constructing new or expanded storage in the Trinity River Basin. None of these measures would be implementable in 2017, and would take several years or more to plan, design, and construct. While additional storage in the Trinity River Basin could alleviate some of the impacts associated with the proposed action, environmental effects related to construction would likely be substantial.

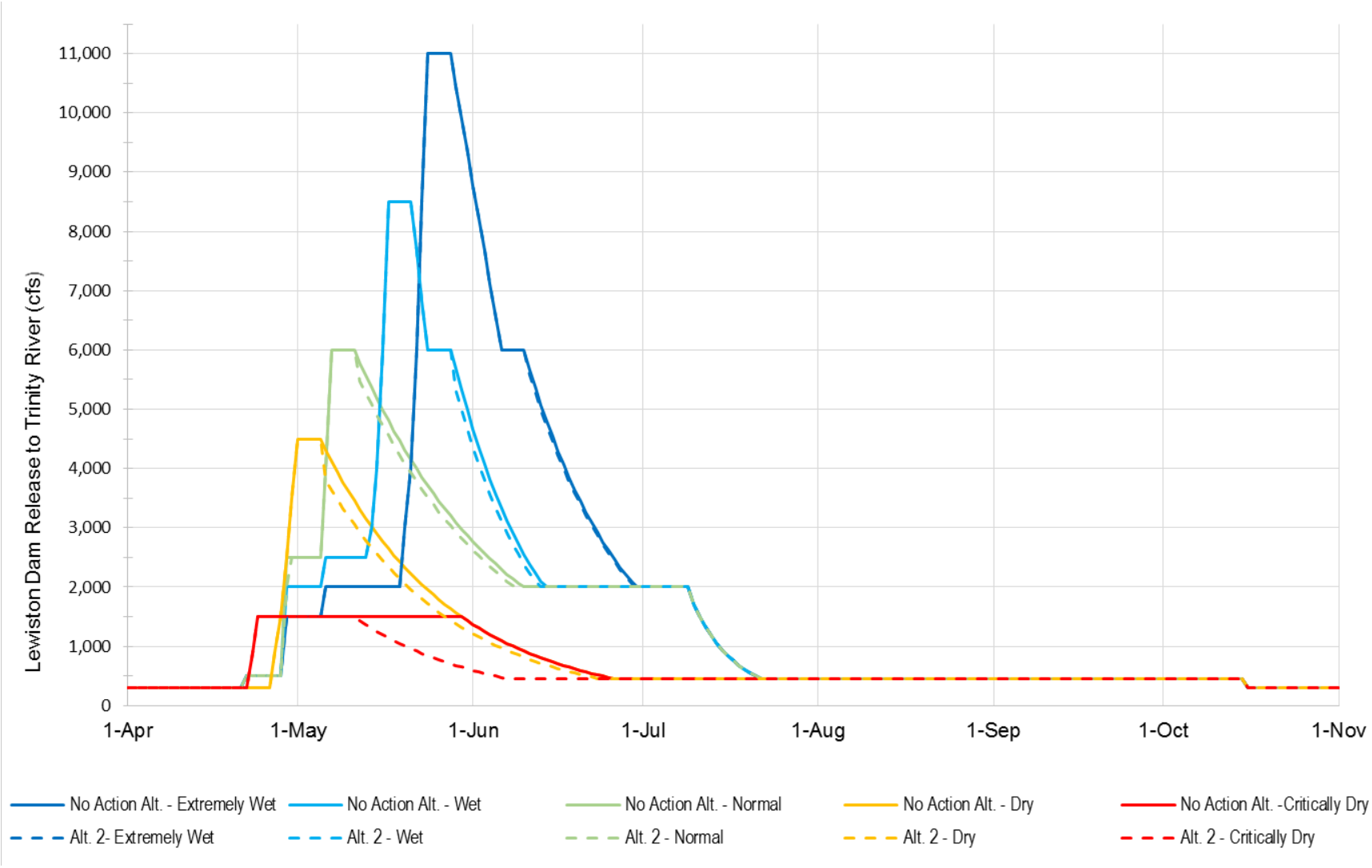

Figure 2-1. Rescheduling of Trinity River ROD Flow Release Pattern for All Year Types Under Alternative 2

Non-Structural Flow Augmentation Measures

Several non-structural alternatives were identified to provide additional flow through reoperating existing facilities or modifying regulatory requirements in the Klamath River Basin. In the Klamath River Basin upstream of the confluence with the Trinity River, these included: reoperating the Klamath Project through prioritizing fishery flows, acquiring water from willing sellers, or providing replacement water supplies; reoperating the Klamath Hydroelectric Project; reoperation of Klamath River tributary facilities; and altering flow requirements under the 2013 Klamath Project BO. Evaluations indicated that increased releases from Klamath River Basin sources would provide limited to no reduction in temperature in the lower Klamath River compared to increased releases from Trinity Reservoir. Since temperature is a significant contributing factor to Ich epizootic events, flow augmentation from Klamath River Basin sources would not be as effective as releases from the Trinity River Subbasin and would not address more than one of the contributing factors to an Ich epizootic event. Further, for the Trinity River Subbasin, non-structural flow augmentation measures that were not carried forward and incorporated into alternatives include: reoperation of storage in Trinity Reservoir based on acquiring water from willing sellers, providing replacement water supplies, modifying Reclamation's Safety of Dams storage restrictions for Trinity Dam, increasing wet year carryover storage in Trinity Reservoir, or carryover storage of Proviso 2 water up to 150 thousand acre-feet. As acquisition of water supplies from willing sellers and providing replacement water supplies from other sources to water users would not reliably provide needed water supplies, these measures would not be able to reliably reduce crowded holding conditions for pre-spawn adults nor reduce warm water temperatures in the lower Klamath River. Modifying Reclamation's Safety of Dams storage restrictions for Trinity Dam would result in unacceptable risks to human health and safety and associated potential for significant impacts due to dam failure. Increasing carryover storage in Trinity Reservoir, either through increasing carryover in wet years or accumulating unused portions of the Humboldt County contract water, would increase operational spills (such releases may not be considered a beneficial use). Additionally, carryover storage of Proviso 2 water implicates CVP system-wide operational criteria and plan that may require modification and a greater scale of analysis to determine potential impacts to the CVP from the potential change in operational criteria and plan. Because of the need for this additional analysis, this proposed alternative is not immediately implementable by August 2017 and as a result, would not meet the purpose and need.

Non-Flow Related Measures

Additional alternatives were identified that consisted of such elements as fisheries management actions, improvement in water quality or temperature, and other measures. These included: reducing hatchery production targets within the Klamath River Basin, including the Trinity River Hatchery; restricting commercial and recreational fishing for Klamath Basin Chinook Salmon and Coho Salmon; removing restrictions to tribal, commercial, and recreational fishing for Klamath Basin Chinook Salmon and Coho Salmon; implement fish passage improvement in the lower Klamath River; implementing a truck-and-transport operation on the lower Klamath River; reducing lower Klamath River flows during the early migration period; directly treating the lower Klamath River for the prominent fish disease (most likely Ich) using chemicals such as chloramine-T, formalin, potassium permanganate, copper sulfate, or sodium chloride; implementing stream habitat enhancement and restoration to reduce water temperature in the lower Klamath River; reconstructing facilities at Lewiston Dam and Reservoir to improve water temperatures; implementing additional water quality standards for agricultural return flow in the

Klamath River Basin to improve water quality to better meet fish needs; and, physically removing all or part of Iron Gate Dam, Copco No. 1 Dam, Copco No. 2 Dam, and JC Boyle Dam, and appurtenant works currently licensed to PacifiCorp. Other non-flow related measures consisted of implementing additional habitat improvement or water quality improvement projects.

Reclamation reviewed each of these concepts, and determined that many of them would not meet the purpose and need for the project, nor did they alleviate one or more of the significant impacts that might be associated with the Proposed Action. Further, none of these concepts would meaningfully and substantially reduce the likelihood, and potentially reduce the severity of Ich epizootic events. Some of these concepts, such as removal of the PacifiCorp dams and reconstructing facilities at Lewiston Dam and Reservoir would not be implementable in 2017. Several of these concepts are already being pursued in different venues, and while they cannot provide a solution on their own, they're part of the larger comprehensive management of the Klamath River system. Many of these elements—such as improving temperature management at Trinity Reservoir—will continue to be pursued in those venues, and Reclamation will support those efforts to the extent practicable.

References

DOI (U.S. Department of the Interior) and Hoopa Valley Tribe. 2000. Record of Decision – Trinity River Mainstem Fishery Restoration. December.

DOI and DFG (U.S. Department of the Interior and California Department of Fish and Game). 2012. Klamath Facilities Removal Final Environmental Impact Statement/Environmental Impact Report. December.

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____. 2015c. Lower Klamath River Late-Summer Flow Augmentation from Lewiston Dam Environmental Assessment. August.

USFWS (U.S. Department of the Interior, U.S. Fish and Wildlife Service). 2015. Response to Request for Technical Assistance Regarding 2015 Fall Flow Releases. Memorandum. August 10.

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Chapter 3
Considerations for Describing Affected Environment and Environmental Consequences

Basis of Environmental Analysis

This Environmental Impact Statement (EIS) addresses effects that would result from the implementation of the action alternatives as compared to the No Action Alternative. The document addresses changes in operations of the Trinity River Division (TRD), and other Central Valley Project (CVP) and State Water Project (SWP) facilities, that could occur between now and 2030 (as described in Chapter 1, "Introduction") if implementing the action alternatives. Implementation of the action alternatives do not include any additional construction or expansion of facilities, therefore there are no construction-related impacts discussed in this EIS.

Resources Considered for Environmental Analysis

Each resource chapter (Chapters 4 through 14) describes the affected environment and the associated direct, indirect, and cumulative impact with implementation of the No Action Alternative and the action alternatives. Potential cumulative effects that would occur with implementation of the alternatives are described in each resource chapter. Potential mitigation measures to avoid, reduce, or otherwise minimize potential adverse impacts to the environment due to implementation of the proposed action and action alternatives are also discussed within each resource area.

The resources included in Chapters 4 through 14 were identified during the scoping process and as described in the 2015 *Scoping Report Long-Term Plan for Protecting Late Summer Adult Salmon in the Lower Klamath River* (Reclamation 2015). The following resources are described and analyzed in this EIS' chapters:

- Chapter 4 "Surface Water Supply and Management"
- Chapter 5 "Surface Water Quality"
- Chapter 6 "Groundwater Resources/Groundwater Quality"
- Chapter 7 "Biological Resources – Fisheries"
- Chapter 8 "Biological Resources – Terrestrial"

- Chapter 9 "Hydropower Generation"
- Chapter 10 "Air Quality, Greenhouse Gas Emissions, and Global Climate Change"
- Chapter 11 "Agricultural Resources"
- Chapter 12 "Socioeconomics"
- Chapter 13 "Indian Trust Assets"
- Chapter 14 "Environmental Justice"

Because the action alternatives would use existing facilities and conveyances, and flow release augmentations would remain within the range of historical releases, there are no obligations under Section 106 of the National Historic Preservation Act as the undertaking does not have the potential to effect historic properties, pursuant to 36 CFR § 800.3(a)(1). As a result, there would be no substantial impacts to historic properties from the action alternatives. Therefore, cultural resources received no further impact analysis under the National Environmental Policy Act.

Scoping comments questioned potential impacts to geology, soils and mineral resources, due to soil subsidence and greater deposits of salts, that negatively affect soil quality by relying more heavily on lower-quality groundwater resources. Both of these potential impacts are addressed in Chapter 6, "Groundwater Resources/Groundwater Quality."

Regulatory Environment and Compliance Requirements

Federal or State regulations relevant to implementation of the alternatives evaluated in this EIS are described in the *Regulatory Environment and Compliance Requirements* portions of Chapters 4 through 14, as appropriate.

Affected Environment

The *Affected Environment* portions of Chapters 4 through 14 provide an adequate level of detail for the quantitative and qualitative impact analyses presented in this EIS.

Implementation of the action alternatives could result in changes to:

- Flow rates and water quality in the lower Klamath River and Trinity River, and associated use of the rivers to support fishery and terrestrial resources and socioeconomics (e.g., commercial and tribal fishing, recreation).
- Flow rates and water quality in rivers downstream of other CVP and SWP reservoirs, and associated use of the rivers to support biological resources.
- Water elevations in TRD reservoirs, and other CVP and SWP reservoirs that store water supplies, and associated use of the reservoir or surrounding areas to support biological resources.

- Flows and water quality in the Sacramento-San Joaquin River Delta (Delta), including Delta outflow and reverse flows, and associated use of the rivers to support beneficial uses.

- CVP deliveries, including associated changes in agricultural production, groundwater use and socioeconomics.

- CVP and SWP energy generation and use, including associated changes in greenhouse gas emissions.

Impact Analysis

The *Impact Analysis* sections in each resource chapter (Chapters 4 through 14) address direct, indirect, and cumulative effects of the alternatives and potential mitigation measures (if necessary and available). The impact analysis includes quantitative and qualitative analyses depending upon the availability of acceptable numerical analytical tools and available information. The quantitative analyses include numerous analytical tools, as summarized in Figure 3-1.

References

Reclamation (U.S. Department of the Interior, Bureau of Reclamation). 2015. Scoping Report Long-Term Plan for Protecting Late Summer Adult Salmon in the Lower Klamath River. Humboldt County, California. November.

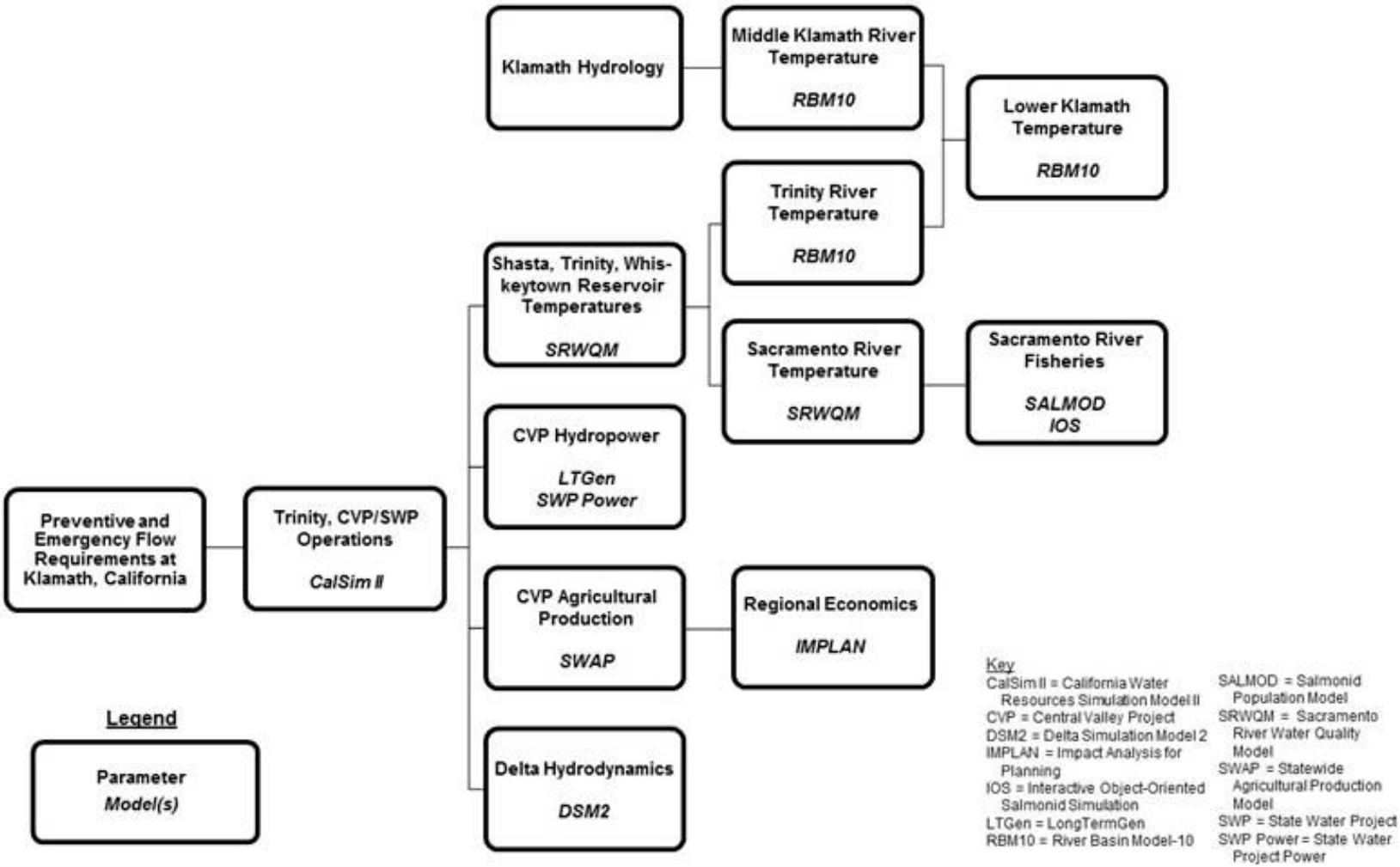


Figure 3-1. Analytical Framework Used to Evaluate Impacts of the Alternatives

Chapter 4
Surface Water Supply and Management

Introduction

This chapter describes the surface water resources and water supplies in the study area and potential changes that could occur as a result of implementing the alternatives evaluated in this Environmental Impact Statement (EIS). Implementation of the alternatives could affect these resources through potential changes in operation of the Central Valley Project (CVP), including the Trinity River Division (TRD), and the State Water Project (SWP), as a result of augmenting flows in the lower Klamath River.

Regulatory Environment and Compliance Requirements

The CVP, including the TRD (e.g., Trinity and Lewiston Dams), and SWP are operated in a coordinated manner in accordance with Public Law 99-546 (October 27, 1986), directing the Secretary to execute the Coordinated Operating Agreement (COA). The COA is an agreement between the Federal government and the State of California for the coordinated operation of the CVP and SWP.

The CVP and SWP are also operated under the State Water Resources Control Board (SWRCB) decisions and water right orders related to Reclamation's CVP and California Department of Water Resources' (DWR) SWP water right permits and licenses to appropriate water by diverting to storage, by directly diverting to use, or by re-diverting releases from storage later in the year or in subsequent years. The CVP and SWP have built water storage and water delivery facilities in the Central Valley to deliver water supplies to CVP and SWP contractors, including senior water users.

Reclamation and DWR water rights are conditioned by SWRCB to protect the beneficial uses of water within the CVP and SWP and jointly for the protection of beneficial uses in the Sacramento Valley and the Sacramento–San Joaquin Delta Estuary. Reclamation and DWR coordinate and operate the CVP and SWP to meet water right and contract obligations upstream of the Sacramento-San Joaquin River Delta (Delta), Delta water quality objectives, and CVP and SWP water right and contract obligations that depend upon diversions from the Delta.

The Porter-Cologne Water Quality Control Act provides for the development and periodic review of water quality control plans that designate beneficial uses of California's major rivers and groundwater basins and establish narrative and numerical water quality objectives for those waters. SWRCB adopted the *1995 Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary*, which was implemented, in part, through the SWRCB Decision 1641 (D-1641). SWRCB D-1641 amends certain terms and conditions of the

SWP and CVP water rights to impose flow and water quality objectives to assure protection of beneficial uses in the Delta and Suisun Marsh. SWRCB also grants conditional changes to points of diversion for each project with SWRCB D-1641.

The CVP and SWP are also operated consistent with the U.S. Fish and Wildlife Service (USFWS) *Formal Endangered Species Act Consultation on the Proposed Coordinated Operations of the Central Valley Project and State Water Project* (2008 USFWS BO) (USFWS 2008) and the National Marine Fisheries Service (NMFS) 2009 *Biological Opinion and Conference Opinion on the Long- Term Operations of the CVP and SWP* (2009 NMFS BO) (NMFS 2009). The 2008 USFWS BO and the 2009 National Marine Fisheries Service (NMFS) BO each included a Reasonable and Prudent Alternative (RPA) to avoid jeopardy to fish species. These RPAs included conditions for revised water operations of the CVP and SWP, habitat restoration and enhancement actions, and fish passage actions.

In addition, Reclamation's Klamath Project is operated consistent the terms and conditions of the UUSFWS and NMFS *Biological Opinion on the Effects of Klamath Project Operations from May 31, 2013, through March 31, 2023, on Five Federally Listed Threatened and Endangered Species* (2013 Klamath BO) (USFWS and NMFS 2013). The 2013 Klamath BO identifies flow and volume targets for Iron Gate Dam releases which affect conditions in the lower Klamath River. Reclamation coordinates closely with PacifiCorp on the releases from Iron Gate Dam.

Affected Environment

This section describes the surface water resources and water supplies that could be potentially affected by the implementation of the alternatives considered in this EIS, including:

- **Surface Water Hydrology** – Storage in Trinity Reservoir and flows in the Trinity River and the lower Klamath River will be directly influenced by the additional augmentation flows released to the Trinity River at Lewiston Reservoir. These additional releases may also change operations at other CVP and SWP facilities due to changes in exports from the TRD to the Sacramento River basin.

- **Deliveries to CVP and SWP Water users** – CVP water delivery may be directly affected by the potential changes in TRD export of water from the Trinity River basin. The changed CVP operations, through changes in Sacramento River flows into the Delta may also affect SWP water operations through the joint operation of CVP and SWP export facilities under the COA.

Additional detailed information on the facilities, current operations, and service areas of the CVP and SWP is provided in the *Coordinated Long-Term Operation of the Central Valley Project and State Water Project EIS* (Reclamation 2015b).

Mean monthly historical data on CVP and SWP operations is presented for the period 2009 to 2016 within the *Affected Environment* section in this chapter. The RPAs in the 2008 USFWS BO and 2009 NMFS BO changed CVP and SWP operations and historical data before that period

may not be representative of current operations. The data is shown as mean monthly values for compatibility with the mean monthly simulated CalSim II data used in the analysis.

Overview of CVP and SWP Water Supply and Water Management Facilities

Overview of the Central Valley Project

With the passage of the Rivers and Harbors Act of 1935, Congress appropriated funds and authorized construction of the CVP by the U.S. Army Corps of Engineers (USACE) (Reclamation 1997, 2011a). When the Rivers and Harbors Act was reauthorized in 1937, the construction and operation of the CVP was assigned to the U.S. Department of the Interior, Bureau of Reclamation (Reclamation), and the CVP became subject to Reclamation Law (as defined in the Reclamation Act of 1902 and subsequent legislation).

The CVP facilities were initiated in the late 1930s (Reclamation 1997, 2011a). The major CVP facilities include:

- Trinity and Lewiston dams on the Trinity River
- Shasta and Keswick dams on the Sacramento River
- Red Bluff Pumping Plant on the Sacramento River to deliver water into the Tehama-Colusa Canal and the Corning Canal
- Folsom and Nimbus dams on the American River and the Folsom-South Canal
- Delta Cross Channel in the Delta
- Rock Slough Intake to deliver water into the Contra Costa Canal, Contra Costa Pumping Plant, and Contra Loma Reservoir
- Friant Dam along the San Joaquin River to deliver water into the Friant-Kern and Madera canals
- C.W. Jones Pumping Plant (Jones Pumping Plant) (previously known as the Tracy Pumping Plant) in the south Delta to deliver water into the Delta-Mendota Canal (DMC) and Mendota Pool
- DMC/California Aqueduct Intertie downstream from the CVP Jones Pumping Plant and the SWP Harvey O. Banks Pumping Plant (Banks Pumping Plant)
- San Luis Reservoir-related facilities include O’Neill Forebay, Pumping Plant, and Canal; Coalinga Canal; Pleasant Valley Pumping Plant; San Luis Drain; B.F. Sisk Dam (the major dam that forms San Luis Reservoir); San Luis Canal; Los Banos and Little Panoche dams; and associated pumping plants. The O’Neill Forebay, B.F. Sisk Dam, San Luis Canal, Los Banos and Little Panoche dams, and associated pumping plants are operated in coordination with the SWP.

- Pacheco Tunnel and Conduit to deliver water from the San Luis Reservoir into the San Justo Dam and Reservoir, Hollister Conduit, and Santa Clara Tunnel and Conduit

- New Melones Dam along the Stanislaus River

Overview of the State Water Project

As the CVP facilities were being constructed after World War II, the State began investigations to meet additional water needs through development of the California Water Plan. In 1957, DWR published Bulletin Number 3 that identified new facilities to provide flood control in northern California and water supplies to the San Francisco Bay Area, San Joaquin Valley, San Luis Obispo and Santa Barbara counties, and southern California (DWR 1957, 2012, Reclamation 2011a). In 1960, California voters authorized the Burns-Porter Act to construct the initial SWP facilities.

The major SWP facilities include:

- Oroville Dam and Thermalito Diversion Dam on the Feather River

- Barker Slough Pumping Plant (BSPP) in the north Delta which delivers water to the North Bay Aqueduct

- Clifton Court Forebay (CCF) and Banks Pumping Plant in the south Delta, which delivers water into the Bethany Forebay and California Aqueduct

- South Bay Pumping Plant to deliver water from Bethany Forebay to the South Bay Aqueduct and Lake Del Valle

- San Luis Reservoir-related facilities, operated in coordination with the CVP, include O'Neill Forebay, B.F. Sisk Dam, San Luis Canal, Los Banos and Little Panoche dams, and associated pumping plants

- California Aqueduct to deliver water to the San Joaquin Valley, Central Coast, and southern California. The California Aqueduct extends from the Banks Pumping Plant to San Luis Reservoir and continues to Lake Perris in Riverside County

Lower Klamath and Trinity River Region

The Lower Klamath and Trinity River Region includes the Trinity River from Trinity Lake to the confluence with the Klamath River and the Klamath River from the confluence with the Trinity River to the Pacific Ocean.

Trinity River

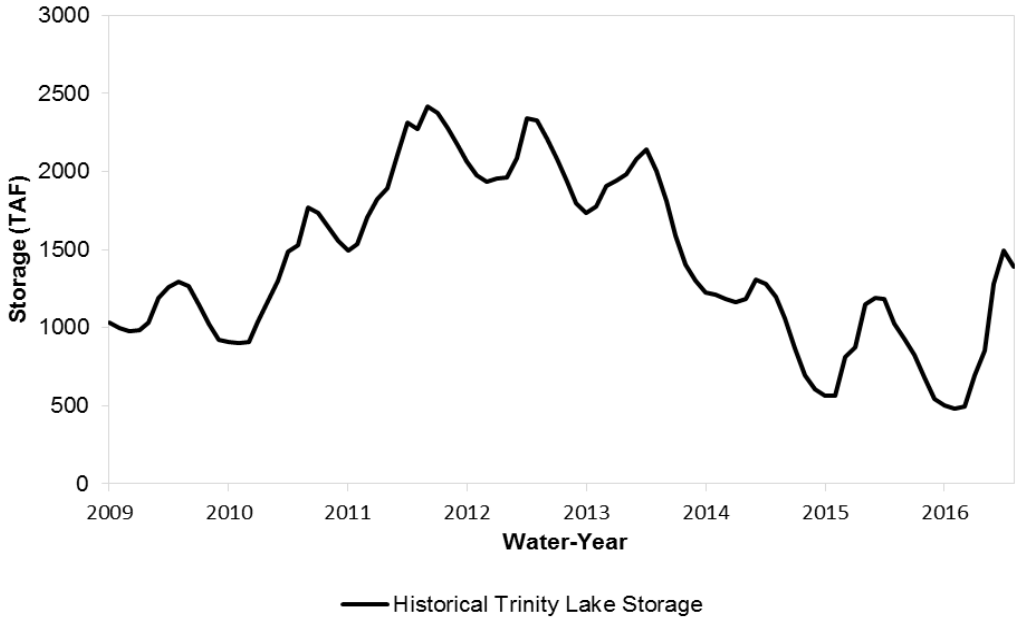
The Trinity River subbasin, part of the Klamath River basin, extends over approximately 1,897,600 acres and ranges in elevation from over 9,000 feet above sea level in the headwaters area to less than 300 feet at the confluence of the Trinity River with the Klamath River (NCRWQCB et al. 2009; USFWS et al. 2000). Average precipitation in the Trinity River subbasin ranges from 30 to 70 inches per year, with a long-term average of approximately 62 inches per year. Over 90 percent of the precipitation has historically occurred between October

and April. Precipitation ranges from mostly snow at higher elevations to mostly rain near the confluence with the 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. The CVP Trinity and Lewiston dams are located at approximately River Miles 105 and 112, respectively; and upstream from 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 Dam to the Klamath River through Trinity and Humboldt counties and the Hoopa Indian Reservation within Humboldt County.

Trinity Lake, a CVP facility on the Trinity River formed by the Trinity Dam, was completed in 1962. The 2.4 million acre-feet (MAF) reservoir is located approximately 50 miles northwest of Redding (USFWS et al. 1999). Lewiston Reservoir, a CVP facility on the Trinity River formed by Lewiston Dam, was completed in 1963 and is located 7 miles downstream from the Trinity Dam. Lewiston Reservoir is used as a regulating reservoir for downstream releases to the Trinity River and to Whiskeytown Lake, located in the adjacent Clear Creek watershed, via Clear Creek Tunnel. Water is diverted from the lower outlets in Trinity Lake to Lewiston Reservoir to provide cold water to Trinity River. There are no other major dams in the Trinity River watershed.

Historical storages in Trinity Reservoir from 2009 to 2016 are presented in Figure 4-1. Trinity Lake storage varies in accordance with upstream hydrology and downstream water demands and instream flow requirements.



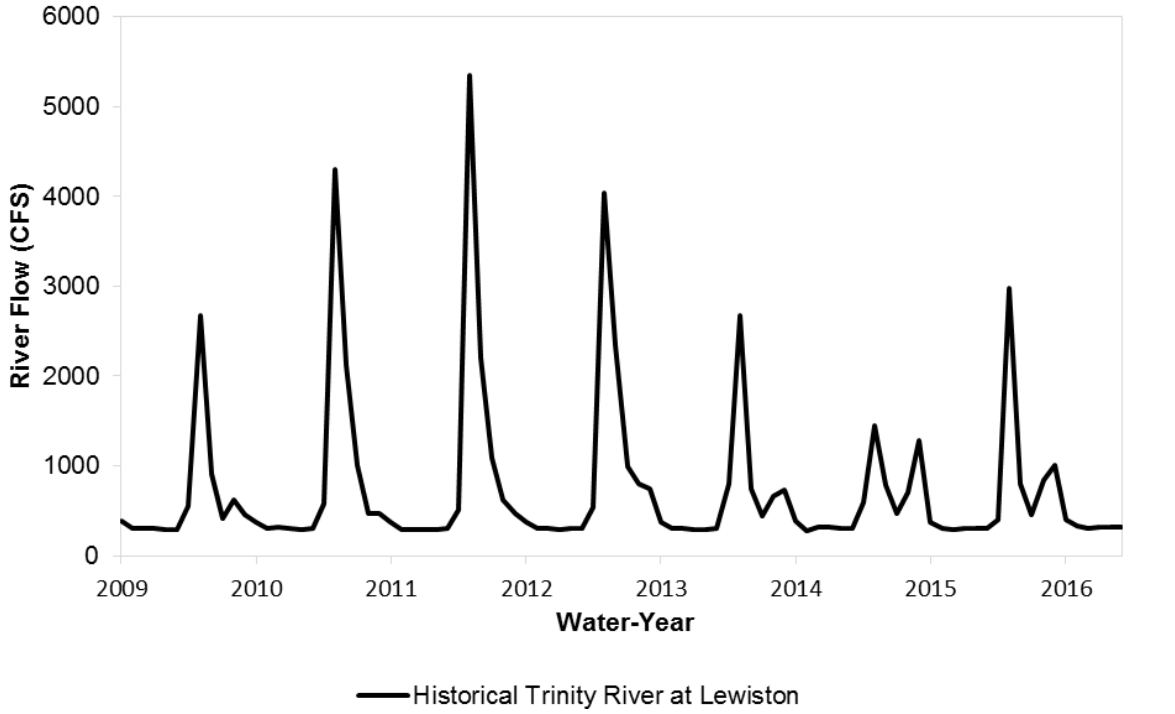
Source: DWR 2016b
Key: TAF = thousand acre-feet

Figure 4-1. Historical Trinity Lake Storage from 2009 to 2016

Prior to completion of Trinity and Lewiston dams, flows in the Trinity River were highly variable and could range from over 100,000 cubic feet per second (cfs) in the winter and spring to 25 cfs in the summer and fall (USFWS et al. 1999). Total annual flow volume at Lewiston (immediately downstream from the current location of Lewiston Dam) ranged from 0.27 to 2.7 MAF with a long-term average of 1.2 MAF.

A large portion of the Trinity River flows upstream from Trinity Lake and Lewiston Dam is exported to the Sacramento River watershed through CVP facilities. The reduction in flows in the Trinity River initially caused substantial reductions in the Trinity River fish populations (USFWS et al. 2000). In response to the reductions in fish populations, Congress enacted legislation and directed that recommendations be developed for the restoration and maintenance of Trinity River fishery. In December 2000, DOI and Hoopa Valley Tribe adopted the *Trinity River Mainstem Fishery Restoration Final EIS/Environmental Impact Report Record of Decision* (ROD), referred to as the Trinity River ROD, for the purpose of restoring Trinity River flow and habitat to produce a healthy, functioning alluvial river system (DOI and Hoopa Valley Tribe 2000). The Trinity River ROD included physical channel rehabilitation; sediment management; watershed restoration; and variable annual instream flow releases from Lewiston Dam based on forecasted hydrology for the Trinity River Basin as of April 1st each year that range from 368,600 acre-feet/year in critically dry years to 815,000 acre-feet/year in extremely wet years. The Trinity River ROD was challenged in United States District Court for the Eastern District of California (District Court); and the changes in operations related to flow were not allowed to proceed while supplemental environmental documentation was prepared and reviewed (NCRWQCB et al. 2009). In 2004, the United States Court of Appeals for the Ninth Circuit entered an opinion that reversed the District Court order; and all actions in the Trinity River ROD were mandated. The flow actions were not completely implemented until several infrastructure projects in the Trinity River channel were completed to protect areas from flood damage. Historical flow in the Trinity River at Lewiston from 2009 through 2016 is presented in Figure 4-2. Historical flow in the Trinity River at Hoopa for 2009 through 2016 is presented in Figure 4-3.

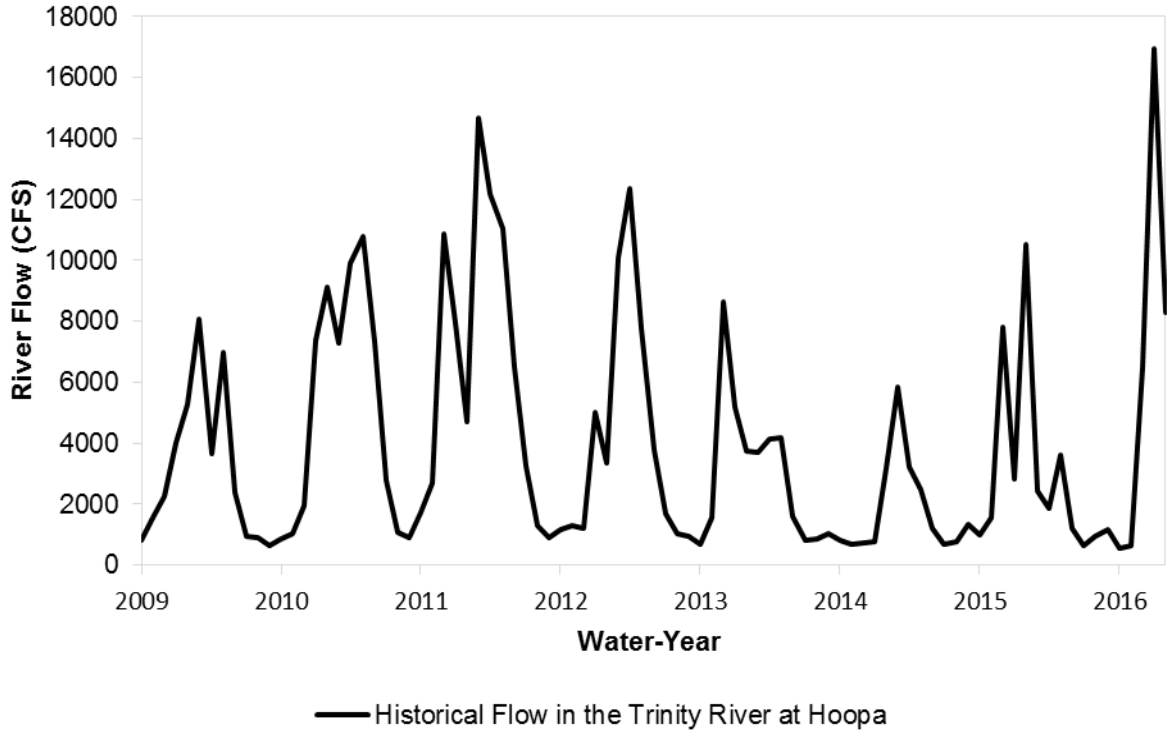
Additional water releases periodically occur into the Trinity River as part of flood control operations and to provide other flow releases (NCRWQCB et al. 2009; Reclamation 2011a). Although flood control is not an authorized purpose of the TRD, flood control benefits are provided through normal operations. The Reclamation Safety of Dams release criteria generally provide for maximum storage in Trinity Lake of 2.1 MAF between November and March. Initial flood releases are discharged from Trinity Lake into Lewiston Reservoir, and then, through the powerplant and into Whiskeytown Lake in the Clear Creek watershed. To reduce the potential for flooding on the Trinity River, releases into Trinity River generally are less than 11,000 cfs from Lewiston Dam (under Safety of Dams criteria) due to local high water concerns in the floodplain and local bridge flow capacities.



Source: USGS 2016b
Key: CFS = cubic feet per second

Figure 4-2. Historical Flow in the Trinity River at Lewiston from 2009 to 2016

Temperature objectives for cold-water fisheries for the Trinity River are set forth in SWRCB Water Rights Order 90-5. These objectives vary by reach and by season. Between Lewiston Dam and Douglas City Bridge, the daily average temperature should not exceed 60 degrees Fahrenheit (°F) from July 1 to September 14, and 56°F from September 15 to September 30. From October 1 to December 31, the daily average temperature should not exceed 56°F between Lewiston Dam and the confluence of the North Fork Trinity River.



Source: USGS 2016g
Key: CFS = cubic feet per second

Figure 4-3. Historical Flow in the Trinity River at Hoopa from 2009 to 2016

Lower Klamath River from Trinity River Confluence to the Pacific Ocean

The Klamath River watershed extends over 15,600 square miles from southern Oregon to northern California, and ranges in elevation from over 9,500 feet above sea level near the headwaters to sea level at the Pacific Ocean (USFWS et al. 1999). The upper Klamath River basin extends over 60 miles from the headwaters to Iron Gate Dam (DOI and DFG 2012). The lower Klamath River basin extends 190 miles from Iron Gate Dam to the Pacific Ocean. Four major tributaries flow into the lower Klamath River, including Shasta, Scott, Salmon, and Trinity Rivers.

As shown in Figure 4-4, the lower Klamath River flows 43.5 miles from the confluence with the Trinity River to the Pacific Ocean (USFWS et al. 1999). Downstream from the Trinity River confluence, the Klamath River flows through Humboldt and Del Norte counties and through the Hoopa Valley Indian Reservation, Yurok Indian Reservation, and Resighini Indian Reservation within Humboldt and Del Norte counties (DOI and DFG 2012). Historical flow in the Klamath River at Orleans from 2009 through 2016 is presented in Figure 4-5.

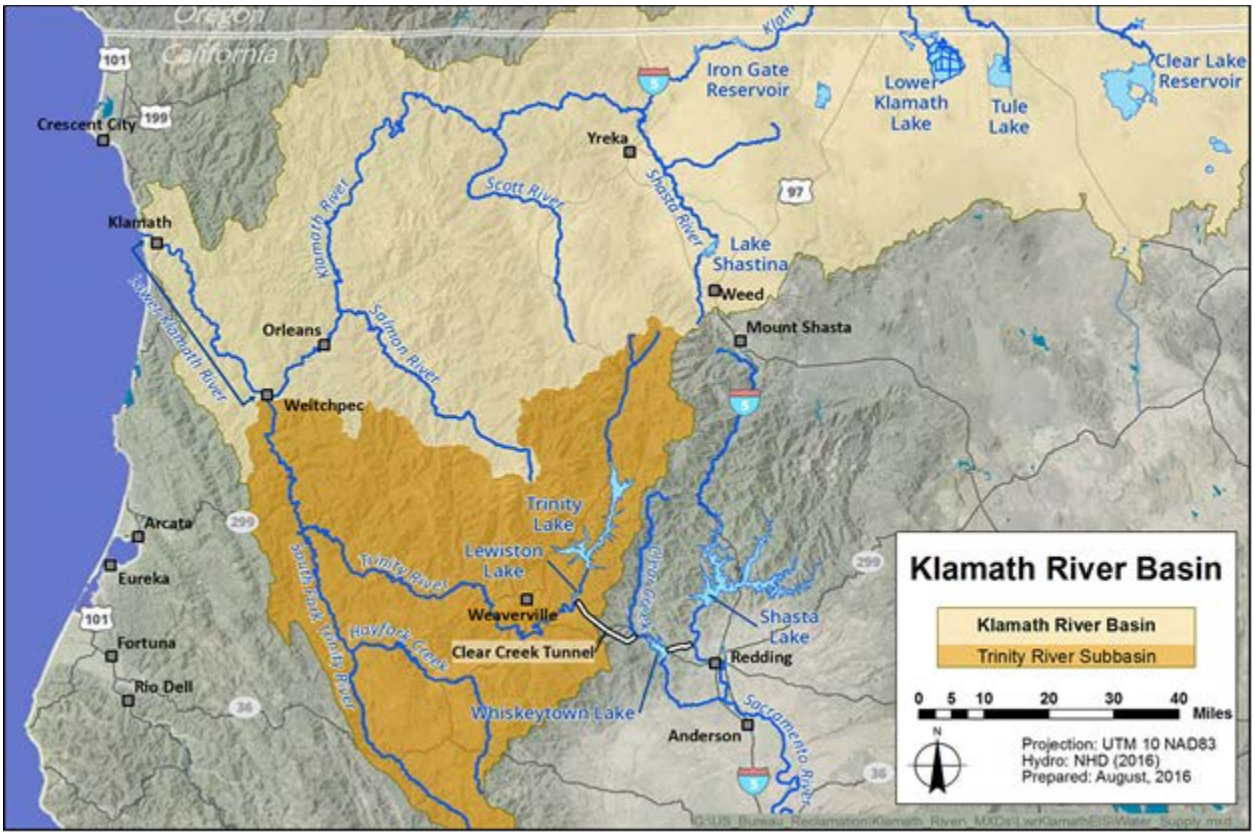
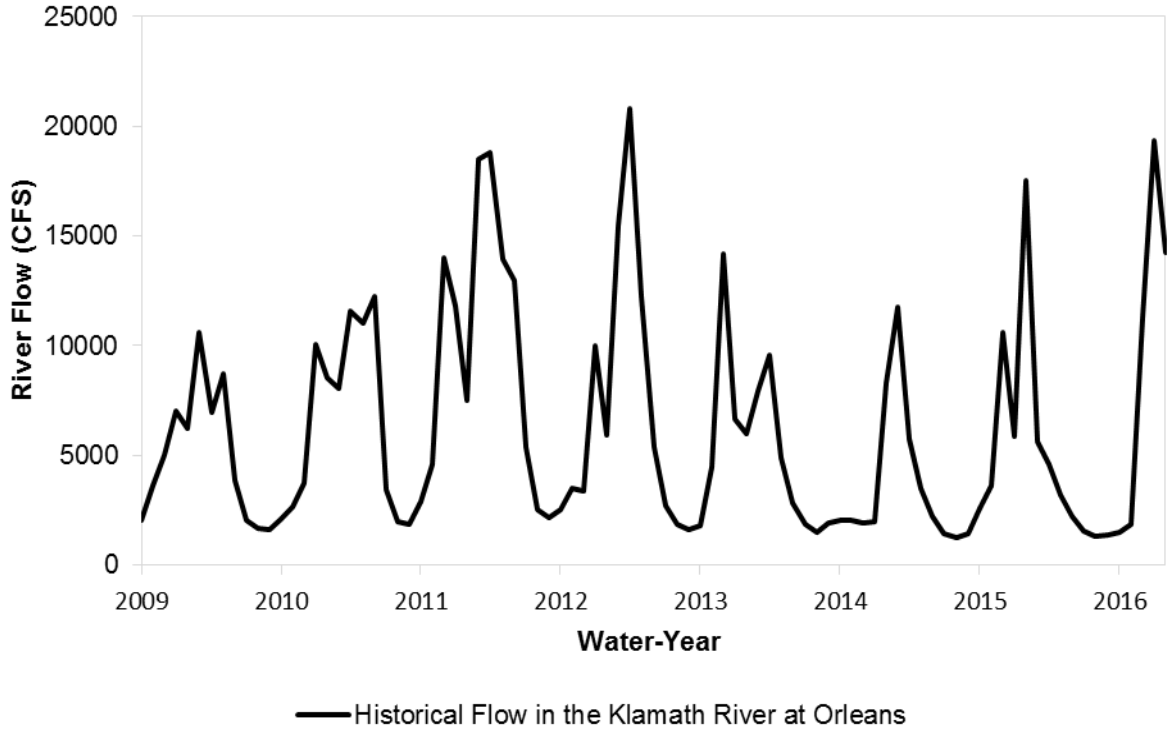


Figure 4-4. Lower Klamath and Trinity Rivers

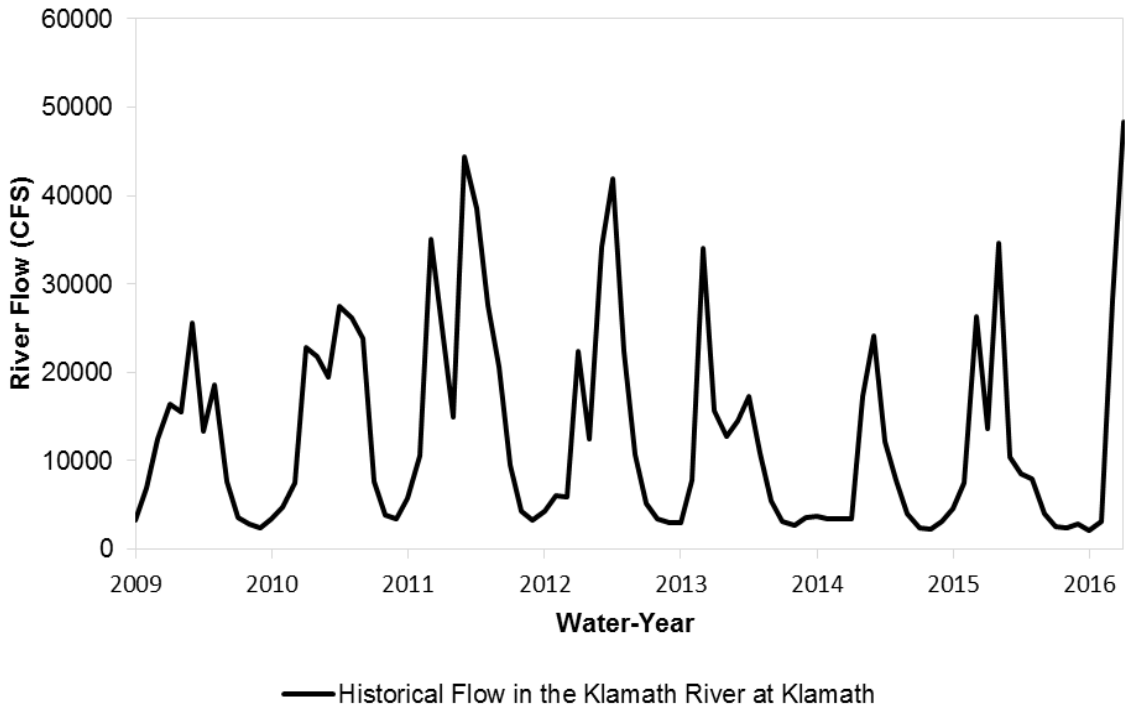


Source: USGS 2016h
Key: CFS = cubic feet per second

Figure 4-5. Historical Flow in the Klamath River at Orleans for Years 2009 to 2016

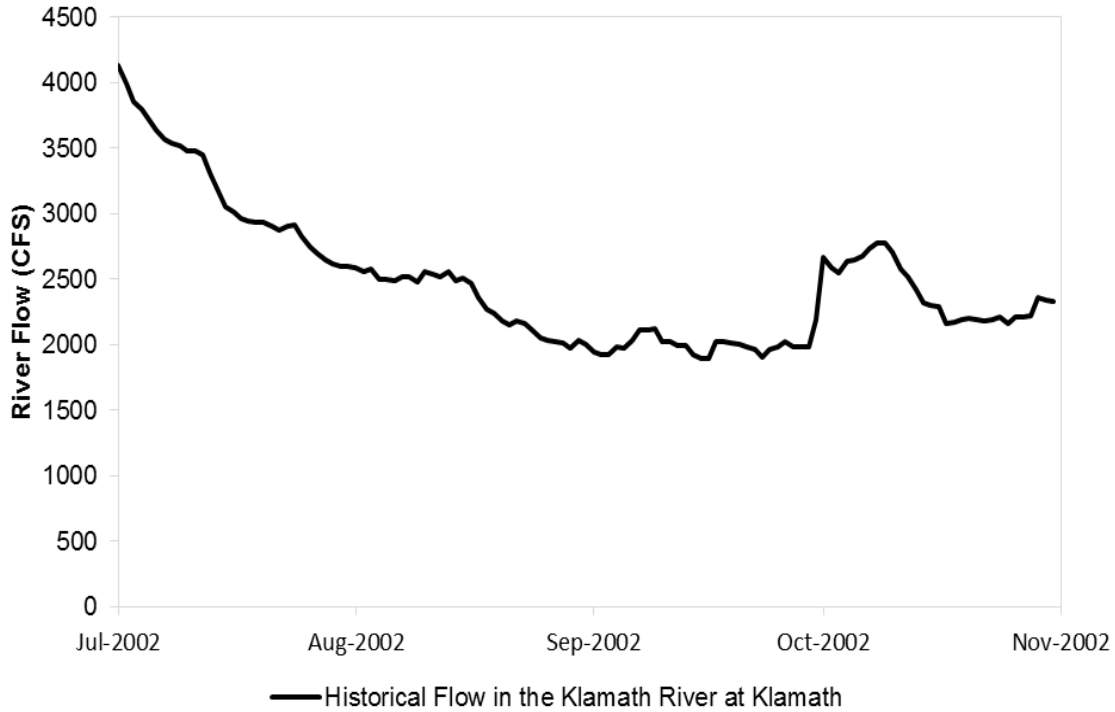
The Trinity River is the largest tributary to the Klamath River (DOI and DFG 2012). There are no dams located in the Klamath River watershed downstream from the confluence with the Trinity River. The western portion of the Klamath River watershed receives substantial rainfall during the winter months. Average precipitation in the western portion of the watershed ranges from 60 to 125 inches per year (Reclamation 2015b; DWR 2013a). Due to the heavy precipitation and the upstream water supply projects in the Klamath River, approximately 85 percent of the flows in the lower Klamath River occur due to runoff in the lower watershed during the winter months (DOI and DFG 2012).

The Klamath River estuary extends for approximately 5 miles upstream from the Pacific Ocean (DOI and DFG 2012). 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. Historical flows in the Klamath River at Klamath from 2009 through 2016 are presented in Figure 4-6. As described in Chapter 1, “Introduction,” Reclamation has periodically released water from Lewiston Dam into the Trinity River to improve late summer flow conditions to avoid fish die-offs in the lower Klamath River or for tribal requirements along the Trinity River (Reclamation 2015a; DOI 2014; TRRP 2014). Figure 4-7 presents historical flows in the Klamath River at Klamath for July through October of 2002, corresponding to the 2002 fish die-off.



Source: USGS 2016i
Key: CFS = cubic feet per second

Figure 4-6. Historical Flow in the Klamath River at Klamath for Years 2009 to 2016



Source: USGS 2016j
Key: CFS = cubic feet per second

Figure 4-7. Historical Flow of the Klamath River at Klamath from July Through October 2002

Central Valley and Bay-Delta Region

The Central Valley and Bay-Delta Region includes the major rivers and waterways downstream from CVP and SWP dams and reservoirs. Major CVP and SWP reservoirs, downstream waterways, and related conveyance facilities (e.g., pump stations and canals) discussed in this section are shown Figure 4-8.

Figure 4-8. Major CVP and SWP Reservoirs, Downstream Rivers, and Conveyance Facilities

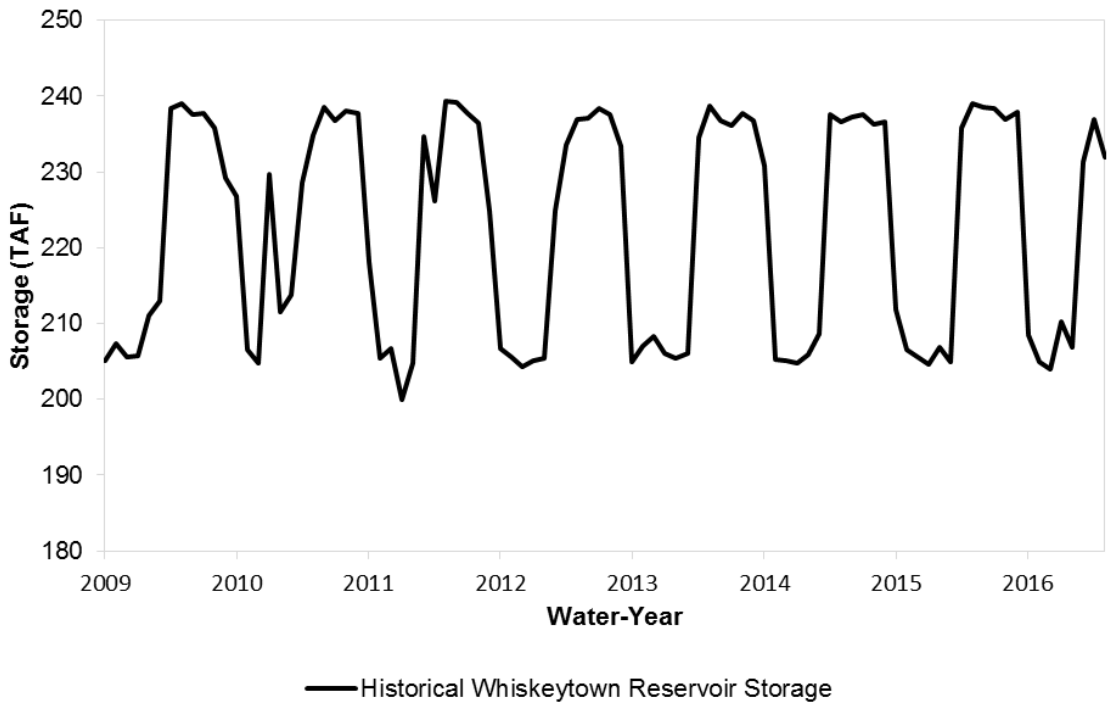
Sacramento Valley

The Sacramento River watershed encompasses an area over 15,360,000 acres in the northern portion of the Central Valley; extending from the foothills of the Coast Ranges and Klamath Mountains on the west to the foothills of the Sierra Nevada and Cascade Range on the east; and extending through the Delta on the south (Reclamation 2013).

The Sacramento River flows approximately 351 miles from the north near Mount Shasta to the confluence with the San Joaquin River at Collinsville in the western Delta (Reclamation 2013). The Sacramento River receives contributing flows from numerous major and minor streams and rivers that drain the east and west sides of the basin. The volume of flow increases as the river progresses southward, and is increased considerably by the contribution of flows from the Feather River and the American River. The Sacramento River also receives imported flows from the Trinity River watershed, as discussed above.

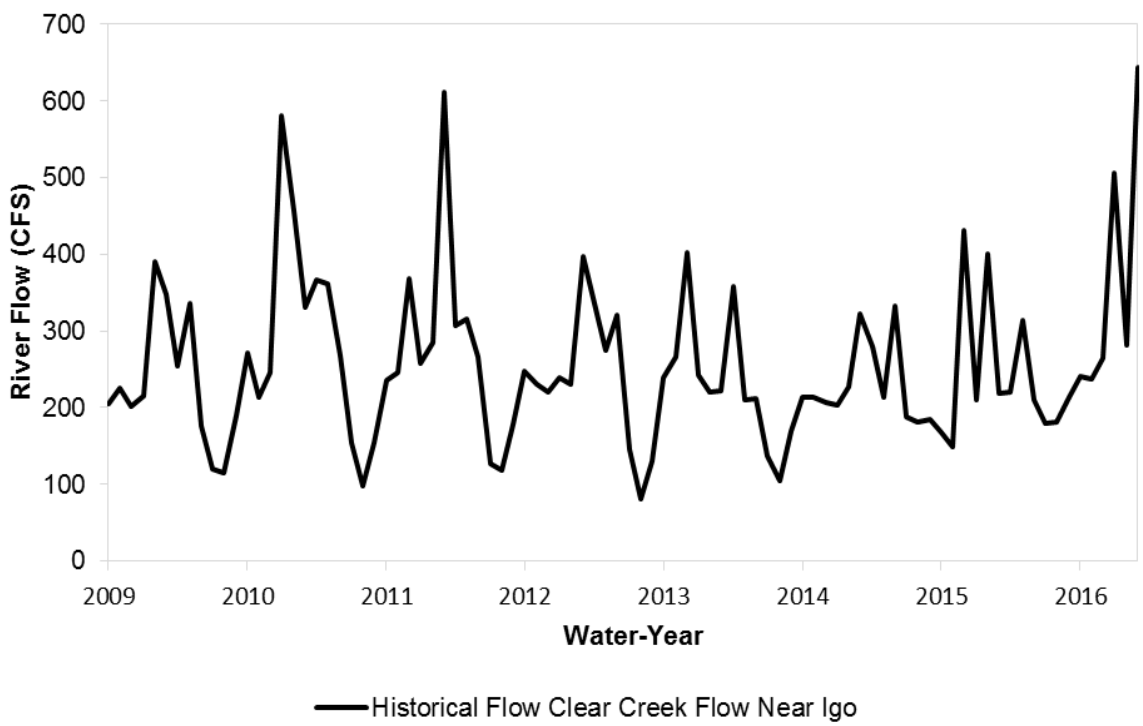
Whiskeytown Dam and Clear Creek Whiskeytown Dam, a CVP facility completed in 1963, is the only dam on Clear Creek and is located approximately 16.5 miles downstream from the headwaters (Reclamation 1997). Whiskeytown Lake, which is formed by the dam, has a storage capacity of 0.241 MAF; and regulates runoff from Clear Creek and diversions from the Trinity River watershed. Flows from Lewiston Reservoir in the Trinity River watershed are diverted to Whiskeytown Lake through the Clear Creek Tunnel. Currently, the Clear Creek Tunnel between Lewiston Reservoir and Whiskeytown Lake has a capacity of 3,200 cfs (Reclamation 2011b). Historical storage in Whiskeytown Reservoir from 2009 through 2016 is presented in Figure 4-9.

Water from Whiskeytown Lake is released to the Sacramento River through the Spring Creek Tunnel which conveys water to the Spring Creek Conduit, and then to Keswick Reservoir. Water from Whiskeytown Lake also is released into Clear Creek directly from Whiskeytown Lake; or during high flow conditions (e.g., flood flows), from a Glory Hole within Whiskeytown Lake through a conduit into Clear Creek. Most of the flows are released through the Spring Creek Tunnel and Powerplant to Keswick Reservoir. These flows into Keswick Reservoir provide cold water flows that reduce temperatures in the upper Sacramento River, especially during the fall months. Water also is discharged from Whiskeytown Lake to Clear Creek to provide for instream flows and water for users located in the CVP Clear Creek South Unit within, or adjacent to, the Clear Creek watershed. In accordance with the 2009 NMFS BO RPA, Reclamation is required to manage Whiskeytown Lake releases to meet daily water temperatures in Clear Creek at Igo. Historical flow in Clear Creek near Igo from 2009 to 2016 is presented in Figure 4-10.



Source: DWR 2016c
Key: TAF = thousand acre-feet

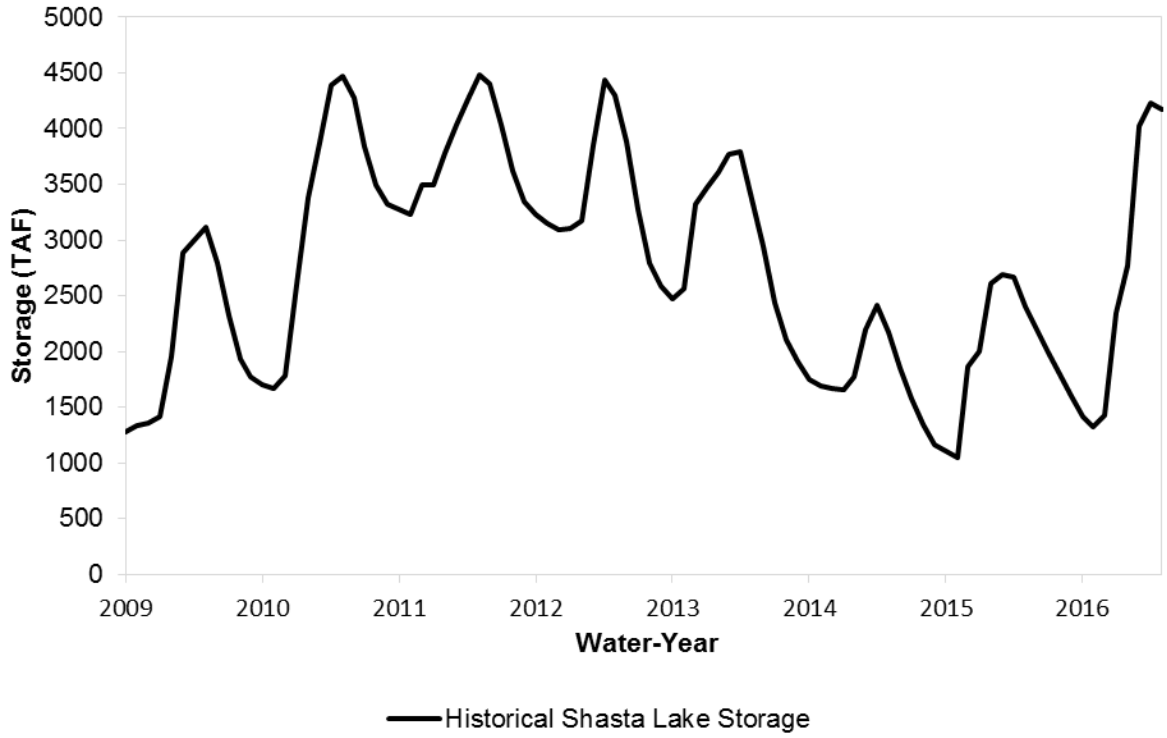
Figure 4-9. Historical Whiskeytown Reservoir Storage from 2009 to 2016



Source: USGS 2016c
Key: CFS = cubic feet per second

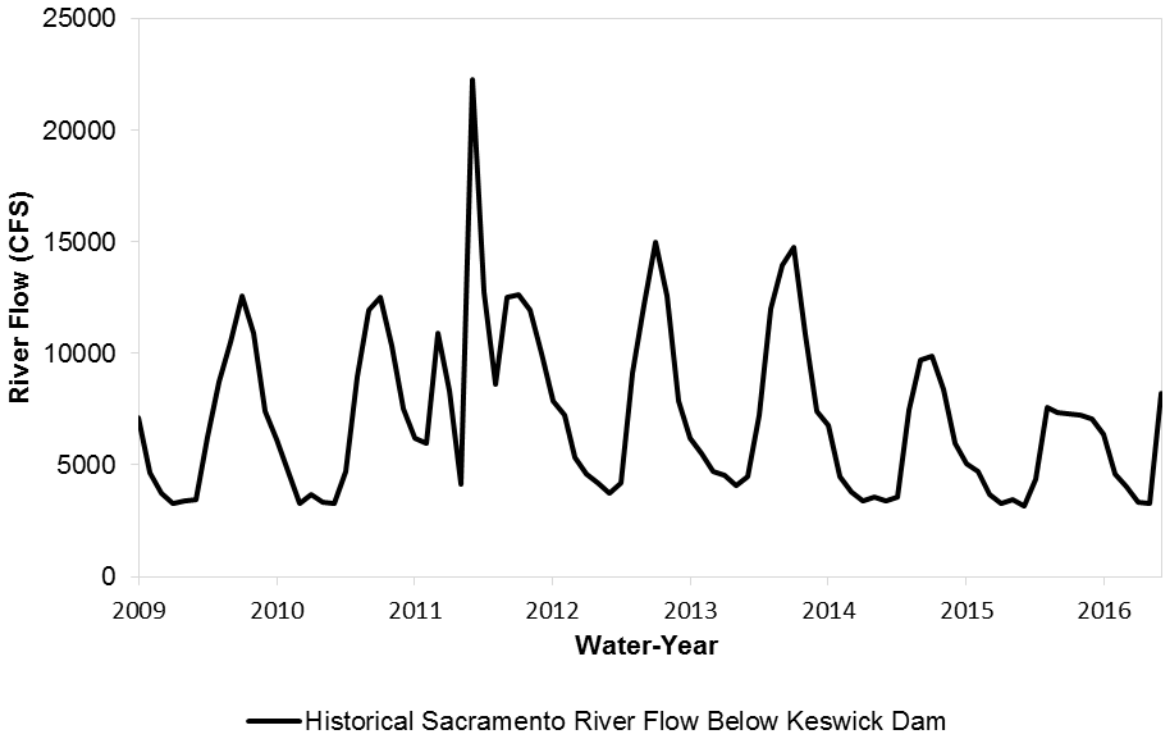
Figure 4-10. Historical Flow in Clear Creek near Igo from 2009 to 2016

Shasta Dam, Keswick Dam and the Sacramento River from Keswick to Red Bluff Shasta Lake, a CVP facility on the Sacramento River formed by Shasta Dam, is located near Redding. Construction on the 4.552 MAF reservoir was completed in 1945. Water flows from Shasta Lake along the Sacramento River into the 0.0238 MAF Keswick Reservoir, a CVP facility, which operates as an afterbay, or regulating reservoir, for Shasta Lake hydropower operations. Construction on Keswick Reservoir was completed in 1950. A temperature control device at Shasta Dam was constructed between 1996 and 1998 to provide cold water without power bypass to the Sacramento River downstream from Keswick Reservoir. Historical storage in Shasta Lake from 2009 to 2016 is presented in Figure 4-11. Historical Sacramento River flows below Keswick Dam from 2009 to 2016 are presented in Figure 4-12.



Source: DWR 2016a
Key: TAF = thousand acre-feet

Figure 4-11. Historical Shasta Lake Storage from 2009 to 2016



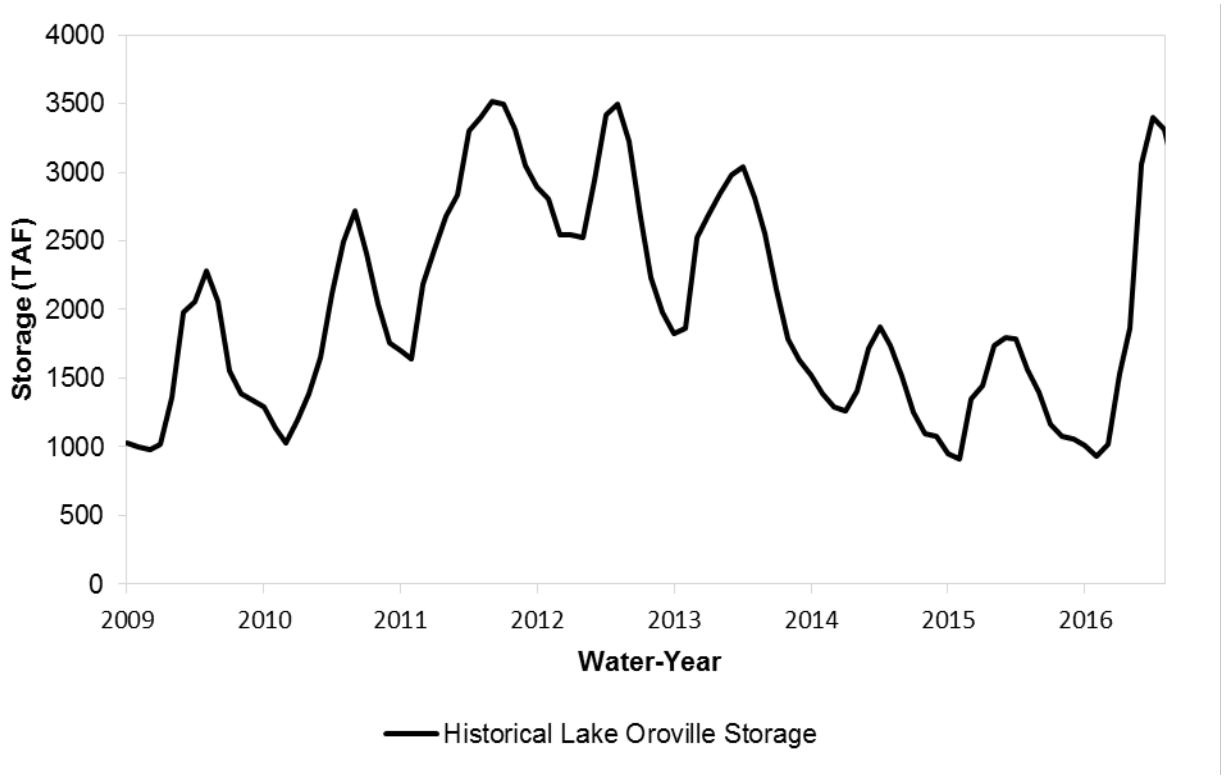
Source: USGS 2016a
Key: CFS = cubic feet per second

Figure 4-12. Historical Sacramento River Flow Below Keswick Dam for Water Years 2009 to 2016

Sacramento River from Keswick Dam to the Delta Water released from Shasta Dam travels approximately 245 miles over three to four days to the northern Delta boundary near Freeport (Reclamation 2013). The upper reach of the Sacramento River flows for approximately 60 miles from Keswick Dam to Red Bluff; and the middle reach of the Sacramento River flows approximately 160 miles from Red Bluff to the confluence with the Feather River. The lower reach of the Sacramento River flows for approximately 20 river miles between the confluence with the Feather River and Freeport, immediately downstream from the confluence with the American River.

Major diversions in this reach of the Sacramento River include the CVP Red Bluff Pumping Plant, Glenn-Colusa Irrigation District (GCID) intake, and individual diversions for the CVP Sacramento River Settlement Contractors. The Red Bluff Pumping Plant was completed in August 2012 to improve fish passage conditions on the Sacramento River by removing the Red Bluff Diversion Dam, and to continue to divert water from the Sacramento River into the Tehama-Colusa and Corning canals. The GCID Main Pump Station is located near Hamilton City to divert water into the GCID Canal that conveys water to over 130,000 acres, including the USFWS Sacramento National Wildlife Refuge; and terminates at the Colusa Basin Drain near Williams. In 2001, the GCID Fish Screen was completed in addition to several canal improvements to allow year-round water deliveries.

Oroville Dam, Thermalito Afterbay and the Feather River The major SWP facility on the Feather River is the 3,500 thousand acre-feet (TAF) Lake Oroville, which is formed by Oroville Dam located at the confluence of the North, Middle, and South forks of the Feather River. Lake Oroville stores winter and spring runoff, which is released into the Feather River to meet SWP water demands; provide pumpback capability to allow for on-peak electrical generation; provide 750 TAF of flood control storage, recreation, and freshwater releases to control salinity intrusion in the Delta; and for fish and wildlife protection. Oroville Dam was completed in 1967. Historical storage in Lake Oroville from 2009 to 2016 is presented in Figure 4-13.

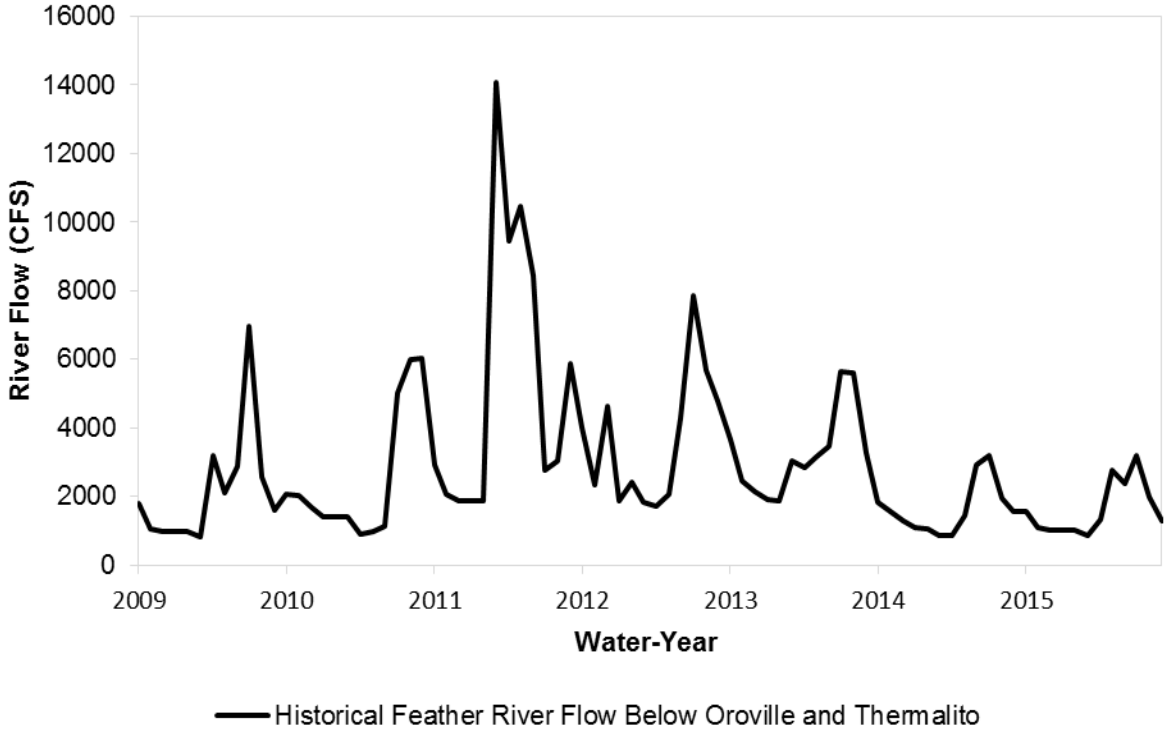


Source: DWR 2016d
Key: TAF = thousand acre-feet

Figure 4-13. Historical Storage in Lake Oroville from 2009 to 2016

Water is released from Lake Oroville through the Edward Hyatt Powerplant into the Thermalito Diversion Pool. The Thermalito Diversion Pool releases water through the Feather River Fish Hatchery which returns water to the Feather River. Additional water is released from the Thermalito Diversion Pool into the Feather River, forming a low flow channel with a relatively constant flow rate for several miles in the Feather River to the confluence with Thermalito Afterbay release. Lake Oroville power releases above the release to the low flow channel are diverted from the Thermalito Diversion Pool into the Thermalito Forebay through a power canal. Water is released from the Thermalito Forebay through the Thermalito Powerplant into the Thermalito Afterbay and then returned to the Feather River at the downstream end of the low flow channel. Water can be pumped back through the Thermalito Powerplant and the Edward Hyatt Powerplant into Lake Oroville when energy prices are low and re-released through the powerplants to generate when energy prices are high. Local agricultural districts also divert

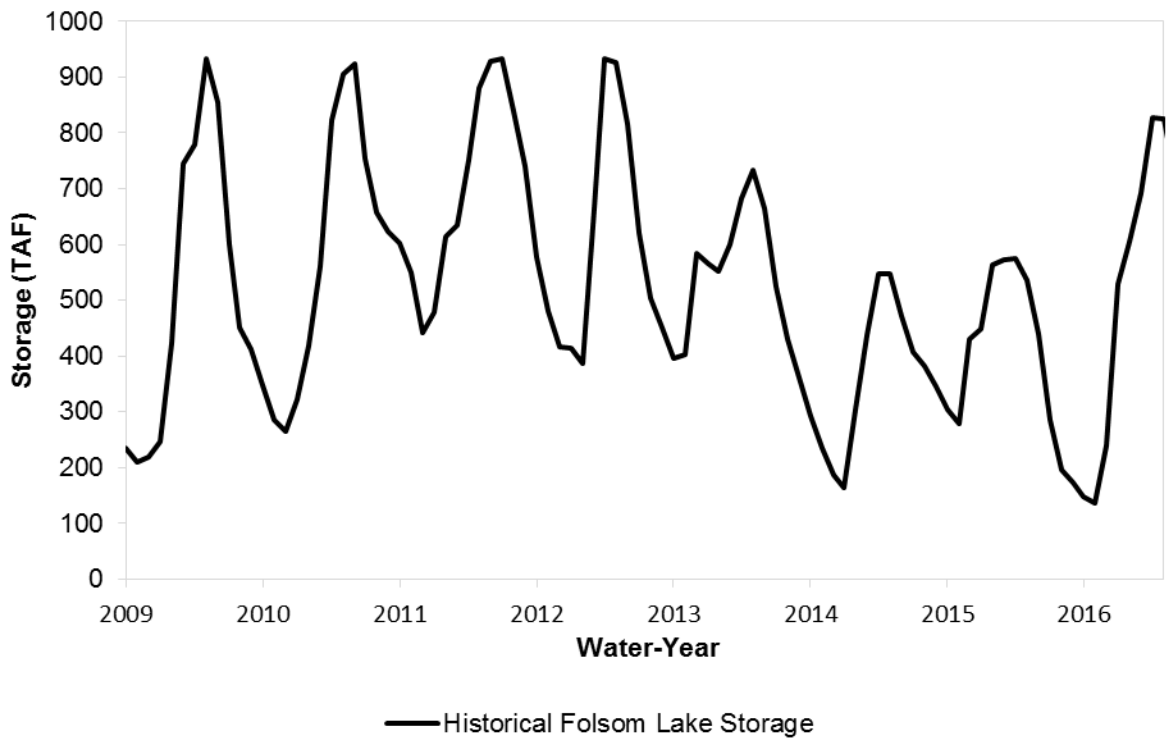
water from the Thermalito Afterbay. Flood releases above the Thermalito Powerplant capacity are made from the Thermalito Diversion Dam into the low flow channel. Historical flows in the Feather River below Oroville Lake and Thermalito Afterbay from 2009 to 2015 are presented in Figure 4-14.



Sources: USGS 2016e, 2016f
Key: CFS = cubic feet per second

Figure 4-14. Historical Feather River Flow below Oroville Lake and Thermalito Afterbay from 2009 to 2015

Folsom Dam, Nimbus Dam, and the American River Folsom Lake and Lake Natoma on the American River are located within portions of the American River watershed that could be affected by changes in CVP and SWP operations. Folsom Lake is a CVP facility formed by Folsom Dam 7 miles upstream from the CVP Nimbus Dam (Reclamation et al. 2006). Folsom, Lake is the largest reservoir in the American River watershed, and has a capacity of 967 TAF. Historical storage levels in Folsom Lake from 2009 to 2016 are presented in Figure 4-15.

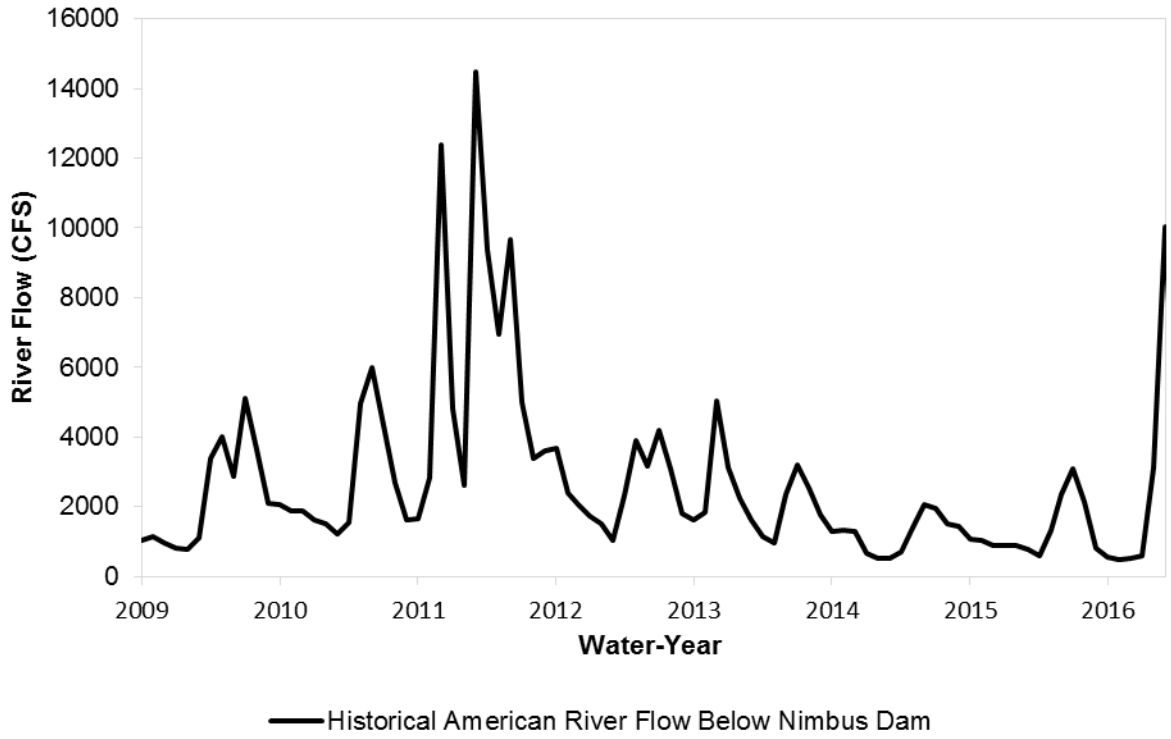


Source: DWR 2016e
Key: TAF = thousand acre-feet

Figure 4-15. Historical Storage in Folsom Lake from 2009 to 2016

Numerous smaller reservoirs in the upper basin provide hydroelectric generation and water supply and are not owned or operated by Reclamation or DWR. The total upstream reservoir storage above Folsom Lake is approximately 820 TAF. Ninety percent of this upstream storage is provided by five reservoirs: French Meadows (136 TAF); Hell Hole (208 TAF); Loon Lake (76 TAF); Union Valley (271 TAF); and Ice House (46 TAF). No impacts are expected to these upper basin facilities.

Nimbus Dam creates Lake Natoma, a forebay built to re-regulate releases from Folsom Lake to smooth flows to the American River and to direct water into the CVP Folsom South Canal. Releases from Nimbus Dam to the American River pass through the Nimbus Powerplant when releases are less than 5,000 cfs or the spillway gates for higher flows. The American River flows 23 miles between Nimbus Dam and the confluence with the Sacramento River. Historical flows in the American River below Nimbus Dam from 2009 to 2016 are presented in Figure 4-16.



Source: USGS 2016d
Key: CFS = cubic feet per second

Figure 4-16. Historical Flows in the American River Below Nimbus Dam from 2009 to 2016

Yolo Bypass Flows from the Sacramento River, Feather River, Sutter Bypass, and Natomas Cross Canal join upstream from Verona on the Sacramento River. When the Sacramento River flows exceed 62,000 cfs, flows spill over the Fremont Weir into the Yolo Bypass. The Yolo Basin was a natural overflow area located to the west of the Sacramento River. The Sacramento River Flood Control Project modified the basin by confining the extent of overflow through a leveed bypass and allowing flood flows to enter the Yolo Bypass from the Sacramento River over the Fremont and Sacramento weirs. The Yolo Bypass conveys floodwaters around the Sacramento metropolitan area and reconnects to the Sacramento River at Rio Vista (DWR 2013b). Tributaries within the Yolo Bypass include the Cache Creek Detention Basin, Willow Slough, and Putah Creek.

Flows also enter the Yolo Bypass from the Colusa Basin, including from the Colusa Basin Drain through the Knights Landing Ridge Cut. In 2011 and 2012, construction at the outfall gates required water from the Colusa Basin Drain to be diverted into the Yolo Bypass. These events temporarily resulted in a fall pulse flow during late August through early October in the Yolo Bypass that increased the volume of flow (e.g., acre-feet) by more than 300 to 900 percent (Frantzich 2014).

San Joaquin Valley

The San Joaquin Valley is divided into two major drainage basins. The northern drainage basin extends from the San Joaquin River along the southern boundary of the Delta and along the lands

adjacent to the San Joaquin River from the northern drainage of the San Joaquin River in Madera County to the southern drainage in Fresno County (DWR 2013a). The northern drainage basin includes the San Joaquin River; five major tributaries that flow westward from the Sierra Nevada, including Fresno, Chowchilla, Tuolumne, Merced, Stanislaus, and Calaveras Rivers; and three major creeks that flow eastward from the Coast Range, including Del Puerto, Orestimba, and Panoche Creek. All flows in the San Joaquin River flow northward to the Delta.

The southern drainage basin (also known as the Tulare Lake Basin) extends into the southern San Joaquin Valley between the Sierra Nevada on the east, Tehachapi Mountains on the south, and the Coast Range on the west (DWR 2013a). The southern basin includes four major tributaries, including Kings, Kaweah, Tule, and Kern Rivers, which drain towards three ancient lakes on the valley floor, including the Tulare, Buena Vista, and Goose lakes. Flows into these lakes have declined as water supply projects and agricultural development has occurred. The northern and southern drainage basins are generally hydrologically separated by a low, broad ridge that extends across the San Joaquin Valley between the San Joaquin and Kings Rivers. However, in flood years, water flows from the Kings River through the James Bypass and Fresno Slough into the San Joaquin River near Mendota; therefore, the basins become hydrologically connected.

Flows from Fresno, Chowchilla, Tuolumne, Merced, Calaveras, Kings, Kaweah, Tule, and Kern rivers contribute substantial flows into the San Joaquin Valley and affect operations of CVP and SWP water users and operations. However, the operations of reservoirs on these rivers are not modified within the alternatives evaluated in this EIS. Therefore, these rivers are not discussed in this chapter. This chapter will focus on the flows in the San Joaquin and Stanislaus rivers that are affected by changes in CVP and SWP operations considered in the alternatives evaluated in this EIS.

Stanislaus River The Stanislaus River originates in the western slopes of the Sierra Nevada and drains a watershed of approximately 900 square miles. The median annual unimpaired runoff in the basin is approximately 1.08 MAF per year (SWRCB 2012). Snowmelt from March through early July contributes the largest portion of the flows in the Stanislaus River, with the highest runoff occurring in the months of April, May, and June.

The North, Middle, and South forks of the Stanislaus River converge upstream from the CVP New Melones Reservoir. The 2.4 MAF New Melones Reservoir is located approximately 60 miles upstream from the confluence of the Stanislaus River and the San Joaquin River. Water from New Melones Reservoir flows into Tulloch Reservoir (Reclamation 2010). Tulloch Reservoir is owned and operated by the Tri-Dams Project for recreation, power, and flow re-regulation of New Melones Reservoir releases. Water released by Tulloch Reservoir and Powerplant flows downstream to Goodwin Reservoir where water is either diverted to canals to serve Oakdale Irrigation District, South San Joaquin Irrigation District, and Stockton East Water District; or released from Goodwin Reservoir to the lower Stanislaus River (SWRCB 2012).

San Joaquin River Upstream from Stanislaus River Operations of Millerton Lake and the CVP Friant Division will not be modified by changes in CVP and SWP operations under the alternatives considered in this EIS because it is disconnected from the Delta under current conditions. By 2030 the San Joaquin River Restoration Program will be making full releases

from Millerton Lake and will be connected to the Delta; however, Millerton Lake will not be operated to meet any Delta conditions and its operations will not be modified by changes in CVP and SWP operations under the alternatives considered in this EIS.

The CVP Westside contractors can exercise legacy water rights to San Joaquin River water if their CVP allocation is low enough and thereby impact Friant Division allocation. The CalSim II modeling performed in support of this EIS does not include this operation rule so it cannot be evaluated in the context of the analysis. Therefore, Millerton Lake and Friant Division are not analyzed in this EIS.

Delta

The Delta constitutes a natural floodplain that covers 1,315 square miles and drains approximately 40 percent of the State (DWR 2013a). The Delta has a complex web of channels and islands and is located at the confluence of the Sacramento and San Joaquin Rivers.

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. In the late 1800s, local land reclamation efforts in the Delta resulted in the construction of channels and levees that began altering the Delta's surface water flows. Over time, the natural pattern of water flows continued to change as the result of upper watershed diversions and the construction of facilities to divert and export water through the Delta to areas where supplemental water supplies are needed, including densely populated areas such as San Francisco and Southern California and agricultural regions such as the San Joaquin Valley and Tulare Lake. The SWP and CVP use the Delta as the hub of their conveyance systems to deliver water to large pumps located in the southern Delta.

Inflows to the Delta occur primarily from the Sacramento River system and Yolo Bypass, the San Joaquin River, and other eastside tributaries such as the Mokelumne, Calaveras, and Cosumnes Rivers. In general, in any given year, approximately 77 percent of water enters the Delta from the Sacramento River, approximately 15 percent enters from the San Joaquin River, and approximately 8 percent enters from the eastside tributaries (DWR 1994). The Delta is tidally influenced; rise and fall varies from less than 1 foot in the eastern Delta to more than 5 feet in the western Delta (DWR 2013a). The flows in the western Delta are tidally influenced, with channel flows both towards and away from the ocean during a tidal cycle and the net flow towards the ocean. Reverse flows are assumed to occur when the net flow in the Old and Middle Rivers (OMR) is away from the ocean.

Hydrological conditions in the Delta are substantially affected by structures that route water through the Delta towards the major Delta water diversions in the south Delta, including the CVP Jones Pumping Plant, the SWP Banks Pumping Plant, the CVP Contra Costa Canal Pumping Plant at Rock Slough, and the Contra Costa Water District (CCWD) intakes on Old and Middle Rivers. These structures are operated to protect Delta water quality for these intakes, the SWP BSPP in the north Delta and over 1,800 municipal and agricultural in-Delta diversions (DWR 2010). These structures include the Delta Cross Channel and temporary barriers in the south Delta. Diversion patterns for the major facilities also are regulated to maintain Delta water quality and to protect fish and wildlife that are listed as threatened or endangered species under

the Federal Endangered Species Act in accordance with the SWRCB D-1641, 2008 USFWS BO, and the 2009 NMFS BO.

CVP Jones Pumping Plant The CVP Jones Pumping Plant, located about 5 miles north of Tracy, has a permitted diversion capacity of 4,600 cfs and sits at the end of a 2.5-mile long earth-lined intake channel that extends to Old River. Water diverted at the Jones Pumping Plant is discharged to the CVP DMC.

SWP Clifton Court and Banks Pumping Plant The SWP facilities in the southern Delta include the 31 TAF CCF, located about 10 miles northwest of the city of Tracy, and the Banks Pumping Plant. Water is diverted from Old River into CCF that provides storage for off-peak pumping, moderates the effect of the pumps on the fluctuation of flow and stage in adjacent Delta channels, and collects sediment upstream from the Banks Pumping Plant and the California Aqueduct. Water flows from CCF to Banks Pumping Plant which discharges into the California Aqueduct.

The nominal capacity of the Banks Pumping Plant is 10,300 cfs. Permits issued by the USACE regulate the rate of diversion of water into CCF. This diversion rate is normally restricted to 6,680 cfs as a three-day average inflow to CCF and 6,993 cfs as a one-day average inflow to CCF. CCF diversions may be greater than these rates between December 15 and March 15, when the inflow into CCF may be augmented by one-third of the San Joaquin River flow at Vernalis when those flows are equal to or greater than 1,000 cfs.

SWP Barker Slough Pumping Plant The SWP BSPP diverts water from Barker Slough into the SWP North Bay Aqueduct for delivery to the Solano County Water Agency and the Napa County Flood Control and Water Conservation District The current 162.5 cfs North Bay Aqueduct intake with a positive barrier fish screen is located approximately 10 miles from the Sacramento River at the end of Barker Slough.

Contra Costa Water District Intakes The CCWD diverts approximately 127 TAF per year, including approximately 110 TAF under the CVP water service contract. The CCWD diverts water at the CVP Rock Slough Intake, and at the CCWD Mallard Slough, Old River, and Middle River (on Victoria Canal) intakes. All four intakes have positive barrier fish screens. Water from the Old River and Middle River intakes can be diverted to the 160-TAF Los Vaqueros Reservoir when Delta salinity is low. When Delta salinity is high, typically in the fall months, CCWD blends low salinity water from Los Vaqueros Reservoir with water from the Delta to meet CCWD water quality goals. Water from Los Vaqueros Reservoir is also used by CCWD when Delta diversions are restricted.

South of Delta CVP/SWP Distribution System

Upstream from San Luis Reservoir

The California Aqueduct transports water from the Banks Pumping Plant to O'Neill Forebay, from which water can be released to the San Luis Canal, a portion of the California Aqueduct jointly owned by the SWP and CVP; or pumped into San Luis Reservoir at the Gianelli Pumping Plant.

The DMC transports water from the Jones Pumping Plant to a location near the San Luis Reservoir where it can be pumped into the O'Neill Forebay, which can then be and then pumped into San Luis Reservoir by the Gianelli Pumping-Generating Plant, or continue down the DMC.

The DMC/California Aqueduct Intertie between the DMC and the California Aqueduct allows water to flow in both directions between the CVP and SWP conveyance facilities. The DMC/California Aqueduct Intertie achieves multiple benefits, including meeting current water supply demands, allowing for the maintenance and repair of the CVP Delta export and conveyance facilities, and providing operational flexibility to respond to emergencies.

San Luis Reservoir

The 2.027 MAF San Luis Reservoir, formed by Sisk Dam, is jointly operated by Reclamation and DWR, with approximately 0.965 MAF used by the CVP and 1.062 MAF used by the SWP. Water generally is diverted into San Luis Reservoir during late fall through early spring when irrigation water demands of CVP and SWP water users are low and are being met by Delta exports. The CVP diverts water from San Luis Reservoir by the Pacheco Pumping Plant through the Pacheco Tunnel and Pacheco Conduit that conveys water to CVP water service contractors in Santa Clara and San Benito counties.

Downstream from San Luis Reservoir

CVP water from the San Luis Reservoir can be released into the DMC which extends to Mendota Pool on the San Joaquin River. Both CVP and SWP water from the San Luis Reservoir can be released into the first reach of the California Aqueduct, the San Luis Canal that is jointly owned by the SWP and CVP and extends from San Luis Reservoir to Kettleman City. This reach includes Dos Amigos, Buena Vista, Teerink, and Chrisman pumping plants.

The California Aqueduct then continues to convey SWP water into southern California through the Edmonston Pumping Plant, located at the foot of the Tehachapi Mountains, that raises the water 1,926 feet into approximately 8 miles of tunnels and siphons that convey water into Antelope Valley. At that location, the California Aqueduct divides into two branches; the East Branch and the West Branch for conveyance to final delivery locations.

Impact Analysis

Potential Mechanisms for Change in Surface Water Resources and Analytical Methods

The environmental consequences assessment considers changes in surface water resource conditions related to the implementation of the action alternatives as compared to the No Action Alternative.

Changes in CVP and SWP Reservoir Storage, Elevation and Downstream River Flows

Changes in CVP and SWP operations under the alternatives as compared to the No Action Alternative would result in changes to reservoir storage volumes (and elevations) and flow patterns in the downstream rivers. Numerical models are available to quantitatively analyze the changes in CVP and SWP reservoirs and pumping plants in the Central Valley, affected surface water bodies, and deliveries of CVP and SWP water.

Use of CalSim II Model CalSim II is a reservoir-river basin planning model developed by DWR and Reclamation to simulate the operation of the CVP and SWP over a range of hydrologic conditions. For the two action alternatives, the No Action CalSim II simulation was modified to reflect the required releases for flow augmentation from Lewiston Reservoir to the Trinity River. The potential augmentation flows were computed based on an analysis of daily historical flows, modified to incorporate climate change, in the lower Klamath River to identify potential low flow periods that would require augmentation under the action alternatives. The resulting daily augmentation flows were then summed to get a monthly volume that could be input into the CalSim II model to simulate the action alternatives. Figure 4-17 presents the estimated flow augmentation volumes for the action alternatives for the CalSim period of analysis. In Alternative 2, additional modifications were made to reflect rescheduling of a portion of the Trinity River ROD spring flows based on Trinity year type. Details on the procedure to determine the potential augmentation flows and modified ROD flows are included in the Analytical Tools Technical Appendix.

CalSim II model monthly simulation of an actual daily (or even hourly) operation of the CVP and SWP results in several limitations in use of the model results. The model results must be used in a comparative manner to reduce the effects of use of monthly assumptions and other assumptions that are indicative of real-time operations, but do not specifically match real-time operations.

The CalSim II model output is based upon a monthly time step. The results are presented in tables of the mean values for individual months presented as averages by water year type to allow comparisons under the range of hydrologic conditions in the CalSim II simulation period. Water year types are used to classify years with similar hydrologic conditions into groups for historical, planning and operational analysis. Because of differences in the hydrologic conditions between watersheds the water year type definition between the Trinity/Klamath watershed and the Sacramento watershed there are unique water year type classifications for each. The Trinity water year classification system is used for tables of reservoir storage, elevation and downstream river flows for locations in the Lower Klamath and Trinity River Region (based on Trinity River ROD year types). Locations in the Central Valley and Bay-Delta Region use the Sacramento water year classification system (e.g., Sacramento River Index). The water year classification system used for each table is identified in the table title.

The CalSim II model output includes minor fluctuations of up to 5 percent due to model assumptions and approaches. Therefore, if the quantitative changes between a specific alternative and the No Action Alternative are 5 percent or less, the conditions under the specific alternative would be considered to be “similar” to conditions under the No Action Alternative.

Under extreme hydrologic and operational conditions where there is not enough water supply to meet all requirements, CalSim II utilizes a series of operating rules to reach a solution to allow for the continuation of the simulation. It is recognized that these operating rules are a simplified version of the very complex decision processes that CVP and SWP operators would use in actual extreme conditions. Therefore, model results and potential changes under these extreme conditions should be evaluated on a comparative basis between alternatives and are an approximation of extreme operational conditions. As an example, CalSim II model results show simulated occurrences of extremely low storage conditions at CVP and SWP reservoirs during

critical drought periods when storage is at dead pool levels at or below the elevation of the lowest level outlet. Simulated occurrences of reservoir storage conditions at dead pool levels may occur coincidentally with simulated impacts that are determined to be potentially significant. When reservoir storage is at dead pool levels, there may be instances in which flow conditions fall short of minimum flow criteria, salinity conditions may exceed salinity standards, diversion conditions fall short of allocated diversion amounts, and operating agreements are not met.

The Analytical Tools Technical Appendix includes additional detail on the CalSim II model, including incorporation of climate change and sea-level rise.

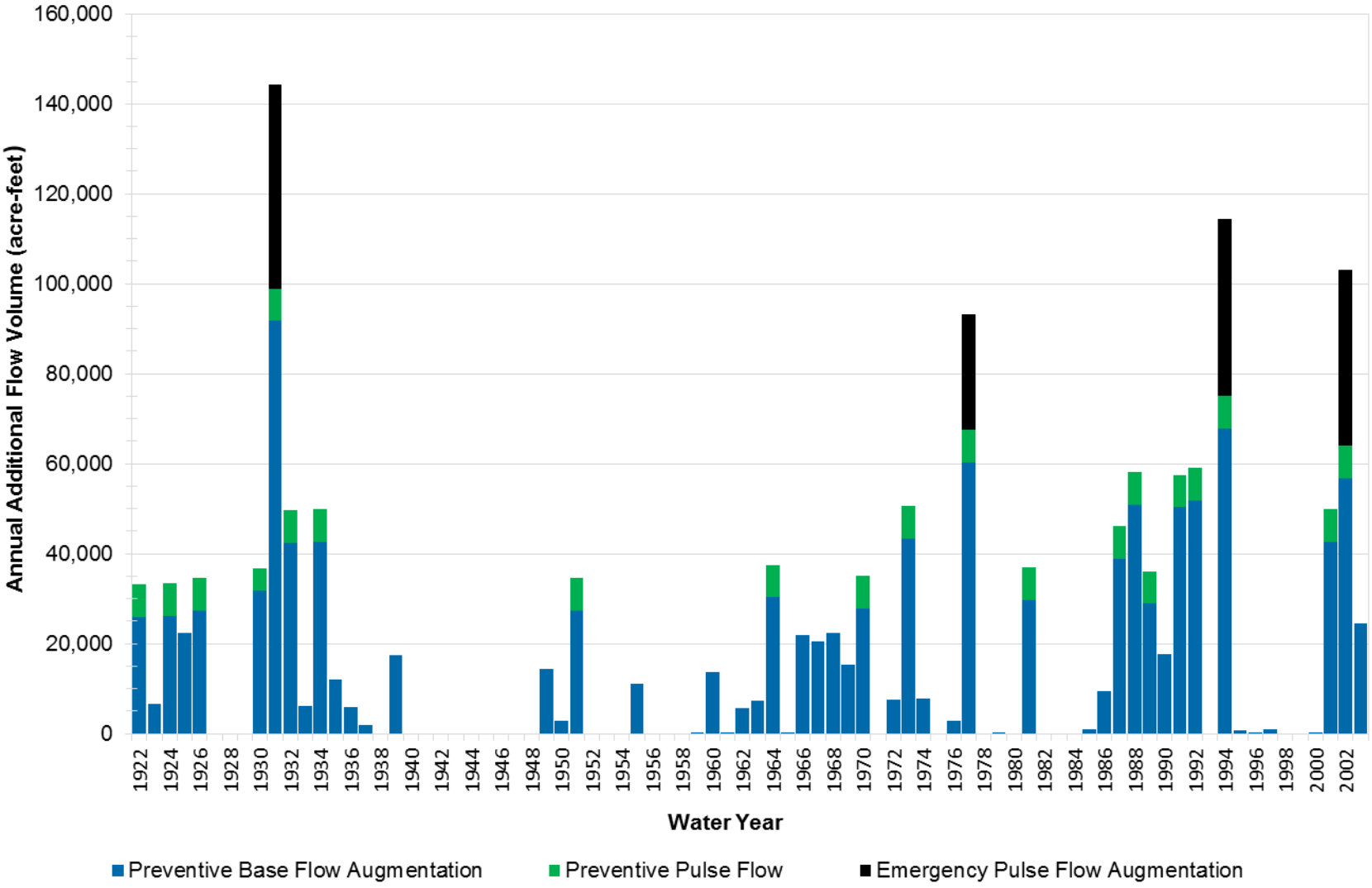


Figure 4-17. Estimated Flow Augmentation Volumes of Action Alternatives for the CalSim Period of Analysis

Analysis of Changes in Reservoir Storage and Downstream River Flows CalSim II outputs for the alternatives are compared to the CalSim II outputs for the No Action Alternative to evaluate changes in reservoir storages at Trinity Lake, Shasta Lake, Lake Oroville, Folsom Lake, New Melones Reservoir, and San Luis Reservoir; flows downstream from CVP and SWP reservoirs in Trinity, Sacramento, Feather, American, Stanislaus Rivers and Clear Creek.

Changes in Delta Conditions

Changes in CVP and SWP operations under the alternatives as compared to the No Action Alternative would change the Delta inflows from the tributary watersheds, Delta outflow, positive and negative flows in OMR(as indicated by OMR flows), and CVP and SWP Delta exports.

Analysis of Changes in Delta Conditions CalSim II output for the alternatives are compared to the CalSim II output for the No Action Alternative to evaluate changes in Delta inflow and outflow, OMR flows and CVP and SWP Delta exports. For details on the CalSim II model and its application see section *Use of CalSim II Model* under section *Changes in CVP and SWP Reservoir Storage and Downstream River Flows* above.

Changes in CVP and SWP Deliveries

Changes in CVP and SWP operations under the alternatives as compared to the No Action Alternative would change CVP and SWP deliveries.

Analysis of Changes in CVP and SWP Deliveries CalSim II output for the alternatives are compared to the CalSim II output for the No Action Alternative to evaluate changes in CVP and SWP Deliveries. For details on the CalSim II model and its application see section *Use of CalSim II Model* under section *Changes in CVP and SWP Reservoir Storage and Downstream River Flows* above.

It should be noted that deliveries to CVP and SWP water users located to the south of the Delta are not necessarily the same volume as the Delta export patterns because a portion of the exported water is stored in San Luis Reservoir and released on a different pattern than Delta exports.

It also should be noted that the monthly CalSim II model results do not represent daily water operations decisions, especially for extreme conditions. For example, in very dry years, the model simulates minimum reservoir volumes (also known as “dead pool conditions”) that appear to prevent Reclamation and DWR from meeting their contractual obligations, including water deliveries to CVP Sacramento River Settlement Contractors, CVP San Joaquin River Exchange Contractors, SWP Feather River Service Area Contractors, and Level II refuge water supplies. Such model results are anomalies that reflect the inability of the monthly model to make real-time policy decisions under extreme circumstances. Projected reservoir storage conditions near dead pool conditions should only be considered as an indicator of stressed water supply conditions, and not necessarily reflective of actual CVP and SWP operations in the future.

Evaluation of Alternatives

The impact analysis in this EIS is based upon the comparison of the action alternatives to the No Action Alternative in the year 2030.

No Action Alternative

Under the No Action Alternative, surface water resources would be comparable to the conditions described in the *Affected Environment* section of this chapter. Conditions in 2030 would be different than existing conditions primarily due to climate change and sea-level rise, general plan development throughout California, and implementation of reasonable and foreseeable water resource management projects to provide water supplies (see Analytical Tools Technical Appendix for additional information).

For the Klamath River Basin, temperatures and precipitation are both anticipated to increase. Climate change may also cause changes in stream flows in the Klamath Basin. Projected warming is anticipated to change runoff timing, with more rainfall runoff during the winter and less runoff during the late spring and summer.

For the Central Valley, 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. For regulated rivers, 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.

Sea-level rise also would result in reduced CVP and SWP reservoir storage. As sea-level rise occurs, the location of the salt water-freshwater zone moves further inland. However, the CVP and SWP must continue to meet 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.

Climate change also would cause changes in stream flows in the Central Valley. During the storm events, the flows would be higher than in recent historical conditions because a larger portion of the precipitation would occur as rainfall instead of snowfall. Flows would increase in the spring as more water is released from CVP and SWP reservoirs to meet Delta salinity criteria. In the summer and fall months, flows could be lower due to reduced amounts of water remaining in reservoir storage.

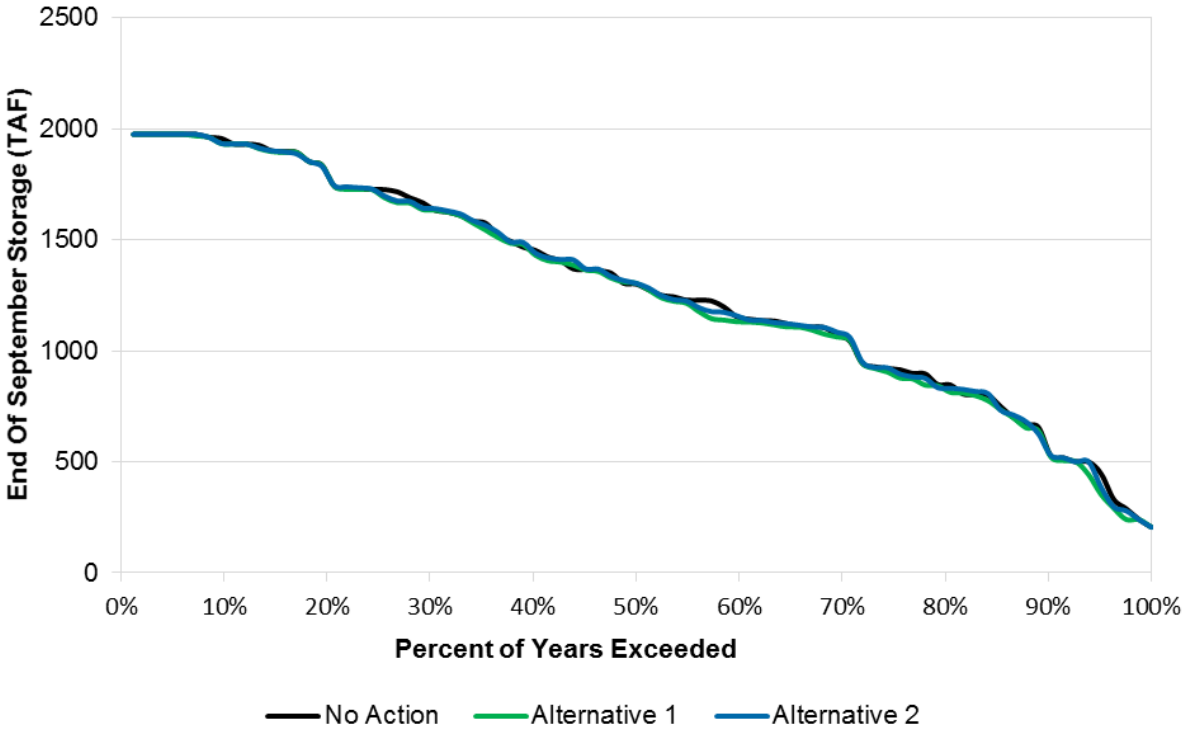
Proposed Action (Alternative 1)

Lower Klamath and Trinity River Region

Changes in CVP and SWP Reservoir Storage, Elevation and Downstream River Flows The Lower Klamath and Trinity River Region is divided into two sub-regions for this analysis, including the Trinity River from Trinity Lake downstream to the confluence with the Klamath River, and the lower Klamath River from the Trinity River confluence to the Pacific Ocean.

Trinity River Changes in the release to the Trinity River from Lewiston Dam would result in changes to Trinity Lake operations and the exports into the Sacramento River basin via Clear Creek Tunnel. Trinity Lake storage and elevation is summarized in Tables 4-1 and 4-2, and

releases from Lewiston Dam to the Trinity River is summarized in Table 4-3. Changes in Trinity River Diversion to Sacramento Basin at Lewiston Reservoir are summarized in Table 4-4. Figure 4-18 is an exceedance curve of Trinity Lake end of September carryover storage.



Key: TAF = thousand acre-feet

Figure 4-18. Trinity Lake End of September Carryover Storage

Trinity Lake storage under Alternative 1 is similar to under the No Action Alternative. Changes in Trinity Lake storage under Alternative 1 have less than a 1 percent decrease except in September of critically dry years where it is a 4 percent decrease.

Trinity Lake elevation under Alternative 1 is similar to under the No Action Alternative with less than 1 percent change in all months of all year types.

Lewiston Dam releases to the Trinity River would increase in August and September in all year types, ranging from 12 percent in August of extremely wet years to 115 percent in September of critically dry years under Alternative 1 as compared to the No Action Alternative. Lewiston Dam releases to the Trinity River would decrease 10 percent in November of extremely wet years, 7 percent in February of Normal years and 10 percent in Octobers of critical dry years under Alternative 1 as compared to the No Action Alternative. The decrease in extremely wet years and in normal years are both driven by a single month in 1974 and 1968 respectively. In these months the release is reduced because storage was lower at the start of the month and water was captured and stored, resulting in the same end of month storage in each case. In both cases these are unique conditions that did not result in substantial changes in subsequent operations and did not violate any operational constraints, including downstream release requirements. The decrease

in critical dry years was reduced because the start of month storage in October 1934, at the end of a major drought, was already at the minimum pool level of 240 TAF which was maintained for the month. This is an example of the extreme conditions where there is not enough water supply to meet all requirements and CalSim II utilizes a series of operating rules to reach a solution to allow for the continuation of the simulation and may not be representative of real time operations under these unique extreme conditions. Releases from Lewiston Dam would be generally similar, less than 5 percent change, under Alternative 1 compared to the No Action Alternative during all other months and year types. The flow increases in August and September are due to release of preventive and emergency flow augmentation releases.

Changes under Alternative 1 as compared to the No Action Alternative in Trinity River Diversions to Sacramento River basin vary by year type and month, ranging from a decrease of 16 percent in July of critically dry years to an increase of 13 percent in March of critically dry years under Alternative 1 as compared to the No Action Alternative. The change in March in critical dry years was due to a change in a single year 1924 and is not expected to occur on a regular basis. The long term changes range from decreases of 7 percent in October to increases of 3 percent in February. These changes do not follow the same pattern as the changes in Lewiston release to the Trinity River because they are dependent both on Trinity Lake conditions and operations and Sacramento Basin operations.

Table 4-1. Changes in Trinity Lake Storage Under Alternative 1 as Compared to the No Action Alternative, by Trinity Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (TAF)												
Extremely Wet	1,197	1,258	1,399	1,618	1,839	1,998	2,208	2,300	2,236	2,105	1,993	1,850
Wet	1,373	1,393	1,507	1,621	1,806	1,952	2,114	2,090	2,018	1,896	1,752	1,606
Normal	1,322	1,324	1,346	1,415	1,529	1,669	1,843	1,773	1,689	1,534	1,386	1,276
Dry	1,096	1,089	1,113	1,127	1,189	1,292	1,403	1,361	1,302	1,159	1,005	901
Critically Dry	1,051	1,016	1,014	988	1,012	1,068	1,087	1,048	985	836	676	598
Average All Years	1,233	1,242	1,306	1,385	1,511	1,637	1,779	1,755	1,686	1,548	1,403	1,283
Alternative 1 (TAF)												
Extremely Wet	1,170	1,236	1,377	1,597	1,821	1,981	2,191	2,285	2,221	2,090	1,979	1,839
Wet	1,362	1,382	1,497	1,613	1,798	1,946	2,107	2,083	2,011	1,890	1,743	1,595
Normal	1,319	1,321	1,343	1,415	1,528	1,669	1,842	1,772	1,689	1,536	1,387	1,266
Dry	1,092	1,085	1,109	1,123	1,184	1,288	1,399	1,357	1,298	1,148	992	881
Critically Dry	1,044	1,007	1,005	979	1,004	1,058	1,078	1,039	976	848	677	576
Average All Years	1,224	1,233	1,298	1,377	1,504	1,631	1,772	1,749	1,680	1,544	1,396	1,269
No Action compared to Alternative 1 (TAF)												
Extremely Wet	-27	-22	-22	-21	-17	-17	-17	-15	-15	-15	-15	-11
Wet	-11	-11	-10	-9	-8	-7	-7	-7	-6	-6	-8	-11
Normal	-3	-2	-3	0	0	0	0	0	0	3	1	-10
Dry	-4	-4	-4	-4	-4	-4	-4	-4	-4	-11	-13	-20
Critically Dry	-7	-9	-9	-9	-8	-9	-9	-9	-9	11	1	-22
Average All Years	-9	-9	-9	-8	-7	-6	-6	-6	-6	-5	-8	-14
No Action compared to Alternative 1 (%)												
Extremely Wet	-2%	-2%	-2%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-1%
Wet	-1%	-1%	-1%	-1%	0%	0%	0%	0%	0%	0%	0%	-1%
Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-1%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	-1%	-1%	-2%
Critically Dry	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	1%	0%	-4%
Average All Years	-1%	-1%	-1%	-1%	0%	0%	0%	0%	0%	0%	-1%	-1%

Key:
TAF = thousand acre-feet

Table 4-2. Changes in Trinity Lake Elevation Under Alternative 1 as Compared to the No Action Alternative, by Trinity Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (feet)												
Extremely Wet	2,268	2,275	2,289	2,311	2,328	2,340	2,355	2,360	2,356	2,347	2,340	2,330
Wet	2,286	2,289	2,299	2,309	2,325	2,336	2,348	2,346	2,341	2,332	2,322	2,310
Normal	2,283	2,283	2,285	2,292	2,302	2,314	2,328	2,323	2,316	2,303	2,291	2,281
Dry	2,254	2,253	2,256	2,258	2,265	2,278	2,290	2,286	2,281	2,268	2,251	2,238
Critically Dry	2,251	2,248	2,248	2,247	2,250	2,257	2,260	2,255	2,249	2,231	2,206	2,194
Average All Years	2,271	2,272	2,278	2,286	2,297	2,309	2,320	2,318	2,313	2,301	2,287	2,276
Alternative 1 (feet)												
Extremely Wet	2,265	2,271	2,287	2,309	2,327	2,339	2,353	2,359	2,355	2,346	2,339	2,329
Wet	2,285	2,287	2,297	2,307	2,324	2,336	2,347	2,346	2,341	2,332	2,321	2,309
Normal	2,282	2,283	2,285	2,292	2,302	2,314	2,328	2,322	2,316	2,304	2,291	2,280
Dry	2,253	2,253	2,256	2,258	2,265	2,277	2,289	2,286	2,281	2,266	2,249	2,235
Critically Dry	2,250	2,247	2,247	2,246	2,249	2,256	2,259	2,254	2,248	2,232	2,206	2,190
Average All Years	2,270	2,271	2,277	2,285	2,297	2,308	2,320	2,318	2,312	2,301	2,286	2,274
No Action compared to Alternative 1 (feet)												
Extremely Wet	-4	-3	-3	-2	-2	-1	-1	-1	-1	-1	-1	-1
Wet	-1	-2	-1	-1	-1	-1	-1	-1	-1	0	-1	-1
Normal	0	0	0	0	0	0	0	0	0	0	0	-1
Dry	-1	-1	-1	-1	-1	0	0	0	0	-1	-2	-3
Critically Dry	-1	-1	-1	-1	-1	-1	-1	-1	-1	2	0	-4
Average All Years	-1	-1	-1	-1	-1	-1	-1	-1	-1	0	-1	-2
No Action compared to Alternative 1 (%)[1]												
Extremely Wet	-1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Critically Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-1%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Note:
[1] Percent change estimated based on the change in active storage elevation (i.e., top of dead pool elevation to top of conservation pool elevation) not the change in total absolute elevation.

Key:
% = percent

Table 4-3. Changes in Trinity River Flow Below Lewiston Dam Under Alternative 1 as Compared to the No Action Alternative, by Trinity Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (cfs)												
Extremely Wet	373	796	930	1,264	1,525	2,458	1,042	4,570	4,626	1,241	450	450
Wet	373	300	1,023	1,175	915	510	481	4,687	2,862	1,102	450	450
Normal	373	300	300	300	385	302	477	4,189	2,120	1,102	450	450
Dry	337	286	300	300	300	300	543	2,848	847	481	450	450
Critically Dry	368	267	300	300	300	300	600	1,498	783	450	450	400
Average All Years	363	359	605	696	668	654	584	3,753	2,210	890	450	445
Alternative 1 (cfs)												
Extremely Wet	373	719	930	1,248	1,455	2,458	1,042	4,570	4,626	1,241	460	477
Wet	373	300	1,024	1,151	910	505	481	4,687	2,862	1,102	503	533
Normal	373	300	300	300	358	302	477	4,189	2,120	1,102	508	632
Dry	337	286	300	300	300	300	543	2,848	847	481	574	725
Critically Dry	332	267	300	300	300	300	600	1,498	783	450	699	861
Average All Years	359	349	605	687	652	652	584	3,753	2,210	890	538	630
No Action compared to Alternative 1 (cfs)												
Extremely Wet	0	-77	0	-16	-69	0	0	0	0	0	10	27
Wet	0	0	1	-24	-5	-5	0	0	0	0	53	83
Normal	0	0	0	0	-27	0	0	0	0	0	58	182
Dry	0	0	0	0	0	0	0	0	0	0	124	275
Critically Dry	-37	0	0	0	0	0	0	0	0	0	249	461
Average All Years	-4	-10	0	-9	-16	-2	0	0	0	0	88	185
No Action compared to Alternative 1 (%)												
Extremely Wet	0%	-10%	0%	-1%	-5%	0%	0%	0%	0%	0%	2%	6%
Wet	0%	0%	0%	-2%	-1%	-1%	0%	0%	0%	0%	12%	18%
Normal	0%	0%	0%	0%	-7%	0%	0%	0%	0%	0%	13%	40%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	28%	61%
Critically Dry	-10%	0%	0%	0%	0%	0%	0%	0%	0%	0%	55%	115%
Average All Years	-1%	-3%	0%	-1%	-2%	0%	0%	0%	0%	0%	20%	42%

Key:
% = percent
cfs = cubic feet per second

Table 4-4. Changes in Trinity River Diversion to Sacramento Basin at Lewiston Reservoir Under Alternative 1 as Compared to the No Action Alternative, by Trinity Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (cfs)												
Extremely Wet	827	233	235	410	7	329	278	498	407	1,836	1,526	2,079
Wet	945	541	376	482	97	322	591	0	290	1,190	1,952	2,065
Normal	792	355	193	418	243	396	228	0	472	1,553	1,991	1,471
Dry	712	418	166	385	134	153	229	247	1,011	1,973	2,098	1,358
Critically Dry	598	609	132	748	168	157	426	378	736	2,028	2,178	949
Average All Years	802	439	241	464	131	276	367	172	575	1,640	1,965	1,648
Alternative 1 (cfs)												
Extremely Wet	766	234	233	410	7	329	278	465	407	1,836	1,513	1,984
Wet	904	551	355	482	100	303	586	0	290	1,181	1,937	2,025
Normal	767	344	196	378	270	396	228	0	469	1,510	1,957	1,471
Dry	636	415	162	387	134	152	229	247	1,008	2,092	2,009	1,196
Critically Dry	521	642	132	753	143	177	426	373	736	1,701	2,092	880
Average All Years	748	443	234	457	134	272	366	167	573	1,623	1,920	1,573
No Action compared to Alternative 1 (cfs)												
Extremely Wet	-61	1	-2	0	0	0	0	-33	0	0	-13	-95
Wet	-42	10	-21	0	3	-20	-5	0	0	-9	-14	-41
Normal	-25	-10	4	-40	27	0	0	0	-3	-43	-34	0
Dry	-75	-3	-4	2	0	-1	0	0	-3	119	-89	-163
Critically Dry	-77	32	0	5	-25	20	0	-4	0	-327	-86	-69
Average All Years	-53	4	-7	-7	3	-4	-2	-5	-2	-16	-45	-74
No Action compared to Alternative 1 (%)												
Extremely Wet	-7%	0%	-1%	0%	0%	0%	0%	-7%	0%	0%	-1%	-5%
Wet	-4%	2%	-6%	0%	3%	-6%	-1%	0%	0%	-1%	-1%	-2%
Normal	-3%	-3%	2%	-10%	11%	0%	0%	0%	-1%	-3%	-2%	0%
Dry	-11%	-1%	-3%	1%	0%	0%	0%	0%	0%	6%	-4%	-12%
Critically Dry	-13%	5%	0%	1%	-15%	13%	0%	-1%	0%	-16%	-4%	-7%
Average All Years	-7%	1%	-3%	-1%	3%	-1%	0%	-3%	0%	-1%	-2%	-5%

Key:
% = percent
cfs = cubic feet per second

Lower Klamath River from Trinity River Confluence to the Pacific Ocean Klamath River flow at the mouth is summarized in Table 4-5. Flows increase in August and September in

all year types except extremely wet, from 4 percent in August of wet years to 183 percent in September of critically dry years. In other months for all year types there were no changes except extremely wet, where there was a 1 percent reduction in February. The increases in August and September are due to flow augmentation releases from Lewiston Dam.

Table 4-5. Changes in the Klamath River near Klamath Under Alternative 1 as Compared to the No Action Alternative, by Trinity Water Year Type (1980-2003)

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (cfs)												
Extremely Wet	2,905	7,625	18,274	27,315	34,866	36,035	23,665	22,135	15,466	6,395	3,011	2,921
Wet	2,764	6,383	18,076	21,408	24,660	20,999	15,107	16,919	9,822	3,790	2,336	2,524
Normal	2,015	6,377	9,388	14,482	11,199	19,978	14,294	11,565	6,057	2,934	1,851	2,064
Dry	2,982	5,483	6,935	7,121	9,172	9,355	8,414	8,101	4,442	2,027	1,800	1,968
Critically Dry	2,476	2,518	3,525	4,859	5,172	7,102	5,632	6,116	3,313	1,706	1,448	1,586
Average All Years	2,765	5,989	12,699	16,046	18,856	18,773	13,664	13,737	8,273	3,451	2,171	2,302
Alternative 1 (cfs)												
Extremely Wet	2,905	7,625	18,274	27,315	34,675	36,035	23,665	22,135	15,466	6,395	3,011	2,924
Wet	2,764	6,383	18,076	21,408	24,660	20,999	15,107	16,919	9,822	3,790	2,372	2,561
Normal	2,015	6,377	9,388	14,482	11,199	19,978	14,294	11,565	6,057	2,934	2,099	2,978
Dry	2,982	5,483	6,935	7,121	9,172	9,355	8,414	8,101	4,442	2,027	1,974	2,434
Critically Dry	2,476	2,518	3,525	4,859	5,172	7,102	5,632	6,116	3,313	1,706	1,787	2,680
Average All Years	2,765	5,989	12,699	16,046	18,823	18,773	13,664	13,737	8,273	3,451	2,287	2,632
No Action Compared to Alternative 1 (cfs)												
Extremely Wet	0	0	0	0	-191	0	0	0	0	0	0	3
Wet	0	0	0	0	0	0	0	0	0	0	35	37
Normal	0	0	0	0	0	0	0	0	0	0	247	914
Dry	0	0	0	0	0	0	0	0	0	0	174	466
Critically Dry	0	0	0	0	0	0	0	0	0	0	339	1,095
Average All Years	0	0	0	0	-33	0	0	0	0	0	116	330
No Action compared to Alternative 1 (%)												
Extremely Wet	0%	0%	0%	0%	-1%	0%	0%	0%	0%	0%	0%	0%
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	2%	1%
Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	13%	44%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	10%	24%
Critically Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	23%	69%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	5%	14%

Key: % = percent cfs = cubic feet per second

Central Valley and Bay-Delta Region

Changes in CVP and SWP Reservoir Storage, Elevation and Downstream River Flows The Central Valley and Bay-Delta Region covers a large geographic area. This section is organized geographically as follows:

- Clear Creek (Whiskeytown Lake, Clear Creek below Whiskeytown)
- Sacramento River (Shasta Lake, Sacramento River below Keswick, Flow Into the Yolo Bypass)
- Feather River (Lake Oroville, Feather River below Oroville and Thermalito Afterbay)
- American River (Folsom Lake, American River below Nimbus Dam)
- San Joaquin River (New Melones, Stanislaus River below Goodwin Dam)

Whiskeytown Dam and Clear Creek Whiskeytown Lake storage is summarized in Table 4-6. Whiskeytown Lake storage under Alternative 1 is similar to the No Action Alternative with changes of less than or equal to 1 percent in all months and year types. As there are no modeled changes to Whiskeytown storage, Whiskeytown Lake elevations under Alternative 1 would also be similar to the No Action Alternative.

Flows in Clear Creek downstream from Whiskeytown Dam are summarized in Table 4-7. Flows in Clear Creek downstream from Whiskeytown Dam under Alternative 1 would be similar to the No Action Alternative with changes less than or equal to 1 percent in all months of all year types.

Table 4-6. Changes in Whiskeytown Lake Storage Under Alternative 1 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (TAF)												
Wet	217	206	206	206	207	218	240	238	240	240	240	235
Above Normal	211	202	205	206	206	217	240	240	239	240	240	235
Below Normal	214	204	204	205	205	217	240	237	240	240	240	235
Dry	215	205	205	204	206	217	239	239	240	237	237	232
Critical	211	202	201	203	204	216	240	240	240	235	220	215
Average All Years	214	204	205	205	206	217	240	239	240	239	236	231
Alternative 1 (TAF)												
Wet	217	206	206	206	207	218	240	238	240	240	240	235
Above Normal	211	202	205	206	206	217	240	240	239	240	240	235
Below Normal	214	204	204	205	205	217	240	237	240	240	240	235
Dry	215	205	205	204	206	217	239	239	240	237	237	232
Critical	211	202	201	203	204	216	240	240	240	235	220	216
Average All Years	214	204	204	205	206	217	240	239	240	239	236	232
No Action compared to Alternative 1 (TAF)												
Wet	0	0	0	0	0	0	0	0	0	0	0	0
Above Normal	0	0	0	0	0	0	0	0	0	0	0	0
Below Normal	0	0	0	0	0	0	0	0	0	0	0	0
Dry	0	0	0	0	0	0	0	0	0	0	0	0
Critical	1	0	0	0	0	0	0	0	0	0	0	1
Average All Years	0	0	0	0	0	0	0	0	0	0	0	0
No Action compared to Alternative 1 (%)												
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Below Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Critical	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Key:
% = percent
TAF= thousand acre-feet

Table 4-7. Changes in Clear Creek Flows Below Whiskeytown Dam Under Alternative 1 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (cfs)												
Wet	200	200	200	309	249	207	200	277	200	85	85	150
Above Normal	181	182	188	192	196	196	196	277	200	85	85	150
Below Normal	195	195	195	195	195	195	195	274	191	85	85	150
Dry	178	184	188	190	190	190	190	267	183	85	85	150
Critical	163	167	167	167	167	167	167	214	111	85	85	133
Average All Years	185	188	190	225	207	194	191	265	181	85	85	148
Alternative 1 (cfs)												
Wet	200	200	200	309	249	207	200	277	200	85	85	150
Above Normal	181	182	188	192	196	196	196	277	200	85	85	150
Below Normal	195	195	195	195	195	195	195	274	191	85	85	150
Dry	178	184	188	190	190	190	190	267	183	85	85	150
Critical	161	167	167	167	167	167	167	214	111	85	85	133
Average All Years	185	188	190	225	207	194	191	265	181	85	85	148
No Action compared to Alternative 1 (cfs)												
Wet	0	0	0	0	0	0	0	0	0	0	0	0
Above Normal	0	0	0	0	0	0	0	0	0	0	0	0
Below Normal	0	0	0	0	0	0	0	0	0	0	0	0
Dry	0	0	0	0	0	0	0	0	0	0	0	0
Critical	-2	0	0	0	0	0	0	0	0	0	0	0
Average All Years	0	0	0	0	0	0	0	0	0	0	0	0
No Action compared to Alternative 1 (%)												
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Below Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Critical	-1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Key:
% = percent
cfs = cubic feet per second

Sacramento River Shasta Lake storage and elevation are summarized in Tables 4-8 and 4-9. Sacramento River Flow Downstream from Keswick Dam is summarized in Table 4-10.

Shasta Lake storage under Alternative 1 is similar to the No Action Alternative with changes of less than or equal to 1 percent in all months and year types.

Shasta Lake elevation under Alternative 1 is similar to the No Action Alternative with changes of less than or equal to 1 percent in all months and year types.

Sacramento River flow downstream from Keswick Dam under Alternative 1 would be similar to the No Action Alternative with most months of all year types changing less than 1 percent, with the exception of a decrease of 2 percent in August of dry years and 4 percent in September of critical years.

Table 4-8. Changes in Shasta Lake Storage Under Alternative 1 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (TAF)												
Wet	2,699	2,718	3,078	3,384	3,639	3,863	4,298	4,460	4,242	3,741	3,414	2,986
Above Normal	2,357	2,373	2,595	3,160	3,451	4,021	4,404	4,429	4,039	3,405	3,069	2,831
Below Normal	2,576	2,537	2,675	3,050	3,430	3,802	4,018	3,952	3,583	3,006	2,649	2,615
Dry	2,343	2,277	2,425	2,619	3,032	3,503	3,735	3,664	3,272	2,745	2,472	2,442
Critical	1,704	1,641	1,725	1,878	2,040	2,282	2,209	2,094	1,723	1,244	983	940
Average All Years	2,396	2,374	2,590	2,897	3,199	3,561	3,834	3,847	3,516	2,981	2,671	2,480
Alternative 1 (TAF)												
Wet	2,698	2,716	3,074	3,381	3,639	3,863	4,299	4,460	4,242	3,740	3,413	2,984
Above Normal	2,354	2,368	2,591	3,158	3,451	4,021	4,404	4,428	4,039	3,406	3,069	2,830
Below Normal	2,576	2,536	2,674	3,050	3,433	3,805	4,022	3,955	3,585	3,013	2,658	2,624
Dry	2,344	2,280	2,428	2,620	3,033	3,504	3,735	3,666	3,274	2,750	2,477	2,443
Critical	1,688	1,627	1,710	1,863	2,023	2,266	2,194	2,079	1,710	1,234	978	929
Average All Years	2,393	2,371	2,587	2,894	3,197	3,559	3,833	3,845	3,515	2,981	2,673	2,479
No Action compared to Alternative 1 (TAF)												
Wet	-1	-2	-4	-3	0	0	0	0	0	-1	-1	-3
Above Normal	-3	-5	-4	-2	0	0	0	0	0	0	0	-1
Below Normal	0	-1	-1	0	3	3	4	2	3	7	8	9
Dry	1	2	3	1	1	0	1	1	2	5	6	1
Critical	-16	-14	-15	-15	-17	-16	-16	-15	-13	-10	-5	-11
Average All Years	-3	-3	-3	-3	-2	-2	-2	-2	-1	0	1	-1
No Action compared to Alternative 1 (%)												
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Below Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Critical	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-1%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Key:
% = percent
TAF = thousand acre-feet

Table 4-9. Changes in Shasta Lake Elevation Under Alternative 1 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (feet)												
Wet	992	993	1,010	1,024	1,034	1,042	1,058	1,064	1,056	1,038	1,025	1,006
Above Normal	968	968	983	1,013	1,026	1,048	1,062	1,063	1,049	1,025	1,010	1,000
Below Normal	987	985	992	1,009	1,025	1,040	1,048	1,045	1,031	1,007	990	989
Dry	970	968	976	987	1,007	1,027	1,037	1,034	1,019	995	982	980
Critical	929	925	931	941	953	970	966	959	936	900	877	873
Average All Years	973	972	983	999	1,013	1,029	1,039	1,039	1,025	1,001	986	977
Alternative 1 (feet)												
Wet	992	993	1,010	1,024	1,034	1,042	1,058	1,064	1,056	1,038	1,025	1,006
Above Normal	967	968	983	1,013	1,026	1,048	1,062	1,063	1,049	1,025	1,011	1,000
Below Normal	987	985	992	1,009	1,025	1,040	1,048	1,045	1,031	1,007	991	989
Dry	970	968	976	987	1,007	1,027	1,037	1,034	1,019	995	982	980
Critical	928	924	930	941	952	969	965	959	935	900	877	873
Average All Years	973	972	983	999	1,013	1,029	1,039	1,039	1,025	1,001	986	977
No Action compared to Alternative 1 (feet)												
Wet	0	0	0	0	0	0	0	0	0	0	0	0
Above Normal	0	0	0	0	0	0	0	0	0	0	0	0
Below Normal	0	0	0	0	0	0	0	0	0	0	0	1
Dry	0	0	0	0	0	0	0	0	0	0	0	0
Critical	-1	-1	-1	-1	-1	-1	-1	-1	0	0	0	-1
Average All Years	0	0	0	0	0	0	0	0	0	0	0	0
No Action compared to Alternative 1 (%)[1]												
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Below Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Critical	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Note:

[1] Percent change estimated based on the change in active storage elevation (i.e., top of dead pool elevation to top of conservation pool elevation) not the change in total absolute elevation.

Key:

% = percent

Table 4-10. Changes in Sacramento River Flow Downstream from Keswick Dam Under Alternative 1 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (cfs)												
Wet	6,818	8,363	11,973	17,356	19,393	16,389	9,092	8,198	10,102	13,287	10,378	13,022
Above Normal	6,075	7,101	7,675	7,991	16,094	7,942	6,236	7,332	11,099	14,708	10,512	9,046
Below Normal	6,653	6,916	4,069	3,777	6,831	4,216	5,631	7,238	11,103	14,132	10,963	5,299
Dry	5,992	6,421	3,860	4,070	3,581	3,828	4,809	6,916	11,036	13,306	9,226	4,580
Critical	4,978	4,601	3,634	3,409	3,563	3,382	6,285	6,445	9,713	11,908	8,895	4,437
Average All Years	6,207	6,944	7,032	8,768	11,012	8,450	6,720	7,363	10,565	13,428	9,980	8,040
Alternative 1 (cfs)												
Wet	6,795	8,372	11,984	17,346	19,345	16,371	9,089	8,183	10,100	13,287	10,371	12,991
Above Normal	6,127	7,139	7,659	7,958	16,057	7,947	6,236	7,332	11,100	14,705	10,499	9,023
Below Normal	6,615	6,928	4,070	3,777	6,803	4,216	5,629	7,255	11,098	14,078	10,918	5,274
Dry	5,989	6,402	3,858	4,061	3,592	3,831	4,806	6,906	11,012	13,233	9,087	4,583
Critical	4,908	4,606	3,645	3,413	3,568	3,382	6,280	6,431	9,686	11,807	8,778	4,257
Average All Years	6,192	6,951	7,034	8,758	10,990	8,446	6,717	7,356	10,554	13,388	9,918	7,998
No Action compared to Alternative 1 (cfs)												
Wet	-23	9	12	-10	-49	-18	-3	-14	-1	0	-7	-30
Above Normal	52	37	-16	-33	-37	5	-1	0	1	-3	-13	-22
Below Normal	-37	12	1	0	-28	0	-2	17	-4	-54	-45	-25
Dry	-3	-19	-2	-9	11	3	-3	-10	-24	-74	-139	3
Critical	-69	6	12	4	6	0	-5	-14	-27	-100	-117	-180
Average All Years	-15	6	2	-10	-21	-4	-3	-7	-11	-40	-61	-42
No Action compared to Alternative 1 (%)												
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	1%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Below Normal	-1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	-1%	-2%	0%
Critical	-1%	0%	0%	0%	0%	0%	0%	0%	0%	-1%	-1%	-4%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-1%	-1%

Key:
% = percent
cfs = cubic feet per second

Feather River Lake Oroville storage and elevation are summarized in Tables 4-11 and 4-12. Flows in the Feather River downstream from the Thermalito Afterbay Return are summarized in Table 4-13.

Lake Oroville storage under Alternative 1 is similar to the No Action Alternative with changes of 1 percent or less in all months of all year types.

Lake Oroville elevation under Alternative 1 is similar to the No Action Alternative with changes of 1 percent or less in all months of all year types.

The Feather River Flow below the Thermalito Afterbay Return under Alternative 1 is similar to the No Action Alternative with changes of 1 percent or less in all months of all year types except for an increase of 6% in June of critical years. The change in OMR was mainly driven by a release from Oroville Dam and related increase in Banks Pumping Plant pumping, which in turn was driven by a slight decrease in SWP San Luis storage. This is a unique occurrence without large consequences that may not have occurred under shorter term real time operation decisions and is not expected to occur on a regular basis.

Table 4-11. Changes in Lake Oroville Storage Under Alternative 1 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (TAF)												
Wet	1,682	1,721	2,177	2,547	2,830	2,942	3,300	3,487	3,441	2,961	2,623	2,109
Above Normal	1,254	1,294	1,461	1,933	2,504	2,894	3,245	3,391	3,227	2,594	2,110	1,653
Below Normal	1,543	1,501	1,513	1,723	2,129	2,404	2,660	2,716	2,531	1,921	1,504	1,295
Dry	1,203	1,153	1,173	1,301	1,578	1,932	2,172	2,203	1,951	1,456	1,277	1,135
Critical	1,081	1,010	1,006	1,095	1,213	1,368	1,397	1,382	1,229	1,025	914	857
Average All Years	1,391	1,381	1,558	1,823	2,142	2,386	2,652	2,747	2,598	2,113	1,813	1,507
Alternative 1 (TAF)												
Wet	1,682	1,722	2,179	2,549	2,830	2,942	3,300	3,487	3,441	2,962	2,624	2,109
Above Normal	1,254	1,294	1,461	1,933	2,504	2,894	3,245	3,391	3,227	2,594	2,110	1,653
Below Normal	1,543	1,501	1,514	1,723	2,130	2,404	2,660	2,717	2,531	1,923	1,505	1,296
Dry	1,203	1,154	1,174	1,302	1,578	1,933	2,172	2,204	1,951	1,456	1,276	1,134
Critical	1,084	1,015	1,013	1,102	1,217	1,375	1,404	1,389	1,230	1,024	913	856
Average All Years	1,391	1,382	1,560	1,825	2,143	2,387	2,653	2,749	2,598	2,113	1,813	1,507
No Action compared to Alternative 1 (TAF)												
Wet	0	1	2	2	0	0	0	0	0	0	0	0
Above Normal	0	0	0	0	0	0	0	0	0	0	0	0
Below Normal	0	0	0	0	0	0	0	0	0	1	1	1
Dry	1	1	0	0	0	0	0	1	0	0	0	-1
Critical	3	5	7	7	4	7	7	7	1	0	0	-1
Average All Years	1	1	2	2	1	1	1	1	0	0	0	0
No Action compared to Alternative 1 (%)												
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Below Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Critical	0%	1%	1%	1%	0%	1%	1%	1%	0%	0%	0%	0%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Key:
% = percent
TAF = thousand acre-feet

Table 4-12. Changes in Lake Oroville Elevation Under Alternative 1 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (feet)												
Wet	743	747	796	833	858	867	890	900	898	867	840	792
Above Normal	694	699	719	775	831	863	886	895	885	839	795	745
Below Normal	730	725	727	752	795	821	844	848	832	774	728	703
Dry	688	682	685	703	737	776	799	802	776	721	700	682
Critical	672	663	662	674	691	710	713	711	691	664	648	639
Average All Years	710	708	728	758	791	815	835	841	827	785	755	723
Alternative 1 (feet)												
Wet	743	747	796	833	858	867	890	900	898	867	840	792
Above Normal	694	699	719	775	831	863	886	895	885	839	795	746
Below Normal	730	726	727	752	795	821	844	848	832	774	728	703
Dry	688	682	686	703	737	776	800	802	776	721	700	682
Critical	673	664	663	675	691	711	714	712	691	664	648	639
Average All Years	710	709	728	758	791	815	835	841	827	785	755	723
No Action compared to Alternative 1 (feet)												
Wet	0	0	0	0	0	0	0	0	0	0	0	0
Above Normal	0	0	0	0	0	0	0	0	0	0	0	0
Below Normal	0	0	0	0	0	0	0	0	0	0	0	0
Dry	0	0	0	0	0	0	0	0	0	0	0	0
Critical	0	1	1	1	1	1	1	1	0	0	0	0
Average All Years	0	0	0	0	0	0	0	0	0	0	0	0
No Action compared to Alternative 1 (%)[1]												
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Below Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Critical	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Note:
[1] Percent change estimated based on the change in active storage elevation (i.e., top of dead pool elevation to top of conservation pool elevation) not the change in total absolute elevation.
Key:
% = percent

Table 4-13. Changes in Feather River Flow Downstream from Oroville Dam and Thermalito Afterbay Under Alternative 1 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (cfs)												
Wet	2,124	1,879	3,257	9,436	11,076	12,309	5,889	6,234	3,138	7,085	5,117	8,426
Above Normal	1,516	908	1,807	1,538	2,670	5,724	1,278	1,376	2,233	8,890	7,005	6,992
Below Normal	2,249	1,218	1,538	795	789	1,124	578	1,114	2,246	8,258	5,756	2,558
Dry	1,773	871	1,233	560	705	495	562	1,096	3,063	6,214	1,790	1,361
Critical	815	619	795	308	611	754	605	942	1,774	2,117	1,097	526
Average All Years	1,767	1,206	1,943	3,524	4,303	5,192	2,373	2,749	2,657	6,589	4,102	4,532
Alternative 1 (cfs)												
Wet	2,124	1,879	3,255	9,432	11,115	12,309	5,886	6,232	3,135	7,073	5,121	8,423
Above Normal	1,494	908	1,803	1,537	2,670	5,724	1,279	1,376	2,232	8,888	7,003	6,992
Below Normal	2,249	1,218	1,538	795	789	1,124	578	1,113	2,245	8,247	5,758	2,559
Dry	1,770	871	1,243	560	705	496	562	1,093	3,069	6,221	1,797	1,362
Critical	817	629	794	308	611	753	604	938	1,885	2,136	1,092	525
Average All Years	1,763	1,207	1,944	3,523	4,315	5,192	2,372	2,747	2,673	6,588	4,104	4,532
No Action compared to Alternative 1 (cfs)												
Wet	0	0	-3	-4	39	0	-2	-2	-3	-12	4	-2
Above Normal	-21	0	-4	-1	0	0	1	0	0	-2	-2	-1
Below Normal	0	0	0	0	0	0	0	-1	-1	-11	2	1
Dry	-3	0	10	0	0	1	-1	-3	6	7	6	2
Critical	1	10	0	0	0	0	-1	-4	110	19	-5	-1
Average All Years	-4	1	1	-2	12	0	-1	-2	16	-1	2	0
No Action compared to Alternative 1 (%)												
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	-1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Below Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dry	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Critical	0%	2%	0%	0%	0%	0%	0%	0%	6%	1%	0%	0%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%

Key:
% = percent
cfs = cubic feet per second

Flows into the Yolo Bypass Flows from the Sacramento River into the Yolo Bypass at Fremont Weir are summarized in Table 4-14.

Flows from the Sacramento River into the Yolo Bypass at Fremont Weir under Alternative 1 are similar to the No Action Alternative, with changes less than or equal to 1 percent in all months of all water year types.

Table 4-14. Changes in Flows into the Yolo Bypass at Fremont Weir Under Alternative 1 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (cfs)												
Wet	180	912	8,417	24,250	28,263	18,803	5,735	289	113	0	0	100
Above Normal	100	100	2,726	6,023	12,784	7,789	1,704	100	100	0	0	100
Below Normal	100	100	241	1,005	3,058	880	294	100	100	0	0	100
Dry	100	100	308	903	2,004	1,396	407	100	100	0	0	100
Critical	100	100	147	528	536	396	106	100	100	0	0	100
Average All Years	125	357	3,230	9,076	11,965	7,713	2,243	160	104	0	0	100
Alternative 1 (cfs)												
Wet	180	914	8,436	24,241	28,229	18,799	5,733	289	113	0	0	100
Above Normal	100	100	2,730	5,997	12,751	7,791	1,704	100	100	0	0	100
Below Normal	100	100	241	1,005	3,068	878	294	100	100	0	0	100
Dry	100	100	308	898	2,006	1,397	407	100	100	0	0	100
Critical	100	100	147	527	534	396	106	100	100	0	0	100
Average All Years	125	358	3,237	9,068	11,951	7,712	2,242	160	104	0	0	100
No Action compared to Alternative 1 (cfs)												
Wet	0	2	19	-9	-34	-4	-2	0	0	0	0	0
Above Normal	0	0	5	-26	-32	3	0	0	0	0	0	0
Below Normal	0	0	0	0	10	-2	0	0	0	0	0	0
Dry	0	0	0	-5	1	1	0	0	0	0	0	0
Critical	0	0	0	0	-2	0	0	0	0	0	0	0
Average All Years	0	0	7	-8	-14	-1	-1	0	0	0	0	0
No Action compared to Alternative 1 (%)												
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Below Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dry	0%	0%	0%	-1%	0%	0%	0%	0%	0%	0%	0%	0%
Critical	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Key:
% = percent
cfs = cubic feet per second

American River Folsom Lake storage and elevation are summarized in Tables 4-15 and 4-16. Changes in flows in the American River downstream from Nimbus Dam are summarized in Table 4-17.

Folsom Lake storage under Alternative 1 is similar to the No Action Alternative, with changes of less than or equal to 2 percent in all months of all water year types.

Folsom Lake elevation under Alternative 1 is similar to the No Action Alternative, with changes of less than or equal to 1 percent in all months of all water year types.

The American River flow below Nimbus Dam is generally similar to Alternative 1 with changes of less than 3 percent in all months of all water year types except for a reduction of 5 percent in July and an increase of 5 percent in September of Critical years. The reduction in July is mainly due to larger reductions in two years, 1989 and 1995, the increase in September is mainly due to a single reduction in 1993 with most other years having no or relatively smaller changes. The changes are not related to within year operations but are unique response to isolated conditions and are not expected to occur on a regular basis.

Table 4-15. Changes in Folsom Lake Storage Under Alternative 1 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (TAF)												
Wet	450	433	514	518	515	632	785	950	938	797	706	574
Above Normal	366	375	427	511	530	640	786	945	883	613	542	471
Below Normal	439	426	464	483	533	619	756	840	775	511	455	434
Dry	384	374	401	418	477	576	688	755	648	490	435	408
Critical	317	299	311	318	365	432	472	481	411	325	267	230
Average All Years	400	389	436	459	489	589	712	818	760	585	516	448
Alternative 1 (TAF)												
Wet	451	433	514	518	515	632	785	950	938	797	706	573
Above Normal	369	375	427	511	530	640	786	945	883	613	542	470
Below Normal	439	426	464	483	533	619	756	840	775	512	457	436
Dry	386	376	402	419	477	576	688	755	648	494	437	410
Critical	317	299	311	318	366	433	473	482	411	329	271	232
Average All Years	401	389	437	459	489	589	712	819	760	587	517	449
No Action compared to Alternative 1 (TAF)												
Wet	0	0	0	0	0	0	0	0	0	0	0	-1
Above Normal	2	0	0	0	0	0	0	0	0	0	0	0
Below Normal	0	0	0	0	0	0	0	0	0	1	2	2
Dry	3	2	1	0	0	0	0	0	0	4	2	3
Critical	0	0	0	0	1	1	1	1	0	4	5	2
Average All Years	1	1	0	0	0	0	0	0	0	2	2	1
No Action compared to Alternative 1 (%)												
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Below Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dry	1%	0%	0%	0%	0%	0%	0%	0%	0%	1%	1%	1%
Critical	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	2%	1%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Key:
% = percent
TAF = thousand acre-feet

Table 4-16. Changes in Folsom Lake Elevation Under Alternative 1 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (feet)												
Wet	408	407	419	419	419	433	449	463	462	449	440	425
Above Normal	393	395	405	418	421	434	449	463	457	430	422	413
Below Normal	406	406	411	414	421	431	446	453	446	416	408	406
Dry	398	398	402	405	414	426	438	444	433	414	406	402
Critical	384	382	387	388	395	405	410	411	400	385	373	366
Average All Years	399	399	407	410	415	427	440	449	443	423	415	406
Alternative 1 (feet)												
Wet	408	407	419	419	419	433	449	463	462	449	440	425
Above Normal	393	395	405	418	421	434	449	463	457	430	422	413
Below Normal	406	406	411	414	421	431	446	453	446	416	408	406
Dry	398	398	402	405	414	426	438	444	433	414	406	403
Critical	384	382	387	388	395	405	410	411	400	386	374	366
Average All Years	400	399	407	410	415	427	440	449	443	424	415	406
No Action compared to Alternative 1 (feet)												
Wet	0	0	0	0	0	0	0	0	0	0	0	0
Above Normal	0	0	0	0	0	0	0	0	0	0	0	0
Below Normal	0	0	0	0	0	0	0	0	0	0	0	0
Dry	0	0	0	0	0	0	0	0	0	1	0	0
Critical	0	0	0	0	0	0	0	0	0	1	1	0
Average All Years	0	0	0	0	0	0	0	0	0	0	0	0
No Action compared to Alternative 1 (%)[1]												
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Below Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Critical	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Note:
[1] Percent change estimated based on the change in active storage elevation (i.e., top of dead pool elevation to top of conservation pool elevation) not the change in total absolute elevation.
Key:
% = percent

Table 4-17. Changes in American River Flows Downstream from Nimbus Dam Under Alternative 1 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (cfs)												
Wet	1,736	3,365	6,769	10,469	10,488	7,194	5,486	5,492	4,111	3,479	2,294	3,238
Above Normal	1,601	2,758	3,643	5,426	7,647	5,971	3,533	2,494	2,348	4,760	1,910	2,082
Below Normal	1,862	2,195	2,227	2,250	4,755	2,165	2,423	1,913	2,131	4,532	1,466	1,200
Dry	1,513	1,733	1,561	1,536	2,119	2,365	2,211	1,937	2,399	2,651	1,433	1,244
Critical	1,238	1,389	1,309	1,065	887	1,010	1,240	1,352	1,779	1,458	1,212	1,027
Average All Years	1,604	2,425	3,595	5,012	5,822	4,243	3,345	3,064	2,807	3,325	1,754	1,971
Alternative 1 (cfs)												
Wet	1,749	3,370	6,766	10,476	10,489	7,194	5,486	5,492	4,111	3,478	2,294	3,249
Above Normal	1,548	2,798	3,641	5,424	7,648	5,975	3,535	2,495	2,349	4,760	1,908	2,091
Below Normal	1,866	2,194	2,225	2,252	4,757	2,166	2,423	1,913	2,131	4,515	1,449	1,203
Dry	1,516	1,747	1,575	1,547	2,129	2,359	2,212	1,940	2,403	2,594	1,458	1,241
Critical	1,240	1,391	1,310	1,066	880	1,010	1,240	1,363	1,793	1,393	1,198	1,077
Average All Years	1,601	2,436	3,597	5,017	5,824	4,242	3,346	3,066	2,810	3,300	1,755	1,983
No Action compared to Alternative 1 (cfs)												
Wet	13	5	-3	7	1	0	0	0	0	0	0	11
Above Normal	-53	40	-2	-3	1	3	1	1	1	0	-1	9
Below Normal	4	-1	-1	1	2	1	0	0	-1	-16	-17	2
Dry	3	13	14	11	10	-7	1	3	4	-57	25	-3
Critical	2	2	1	2	-8	0	0	11	14	-66	-14	50
Average All Years	-3	11	2	5	2	-1	1	2	3	-26	1	12
No Action compared to Alternative 1 (%)												
Wet	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	-3%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Below Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-1%	0%
Dry	0%	1%	1%	1%	0%	0%	0%	0%	0%	-2%	2%	0%
Critical	0%	0%	0%	0%	-1%	0%	0%	1%	1%	-5%	-1%	5%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	-1%	0%	1%

Key:
cfs = cubic feet per second

Stanislaus River New Melones Reservoir storage is summarized in Table 4-18. Changes in flows in the Stanislaus River downstream from Goodwin Dam are summarized in Table 4-19.

New Melones storage under Alternative 1 is similar to the No Action Alternative with changes of 1 percent or less in all months of all year types.

As shown in Table 4-18 no changes in storage are identified at New Melones. Accordingly, New Melones elevations under Alternative 1 are similar to the No Action Alternative with changes of 1 percent or less in all months of all year types.

Flows in the Stanislaus River downstream from Goodwin Dam under Alternative 1 are similar to the No Action Alternative with changes of 1 percent or less in all months of all year types.

Table 4-18. Changes in New Melones Reservoir Storage Under Alternative 1 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (TAF)												
Wet	1,379	1,390	1,454	1,562	1,666	1,724	1,758	1,878	1,968	1,890	1,773	1,703
Above Normal	1,030	1,061	1,125	1,215	1,317	1,407	1,414	1,484	1,467	1,373	1,277	1,232
Below Normal	1,294	1,305	1,326	1,351	1,413	1,438	1,390	1,383	1,359	1,268	1,175	1,133
Dry	1,094	1,094	1,106	1,122	1,156	1,188	1,154	1,132	1,088	997	914	871
Critical	624	623	638	645	662	657	602	555	527	477	432	409
Average All Years	1,132	1,142	1,180	1,237	1,305	1,348	1,338	1,373	1,381	1,300	1,209	1,159
Alternative 1 (TAF)												
Wet	1,379	1,390	1,454	1,562	1,666	1,724	1,758	1,878	1,968	1,890	1,773	1,703
Above Normal	1,030	1,061	1,125	1,215	1,317	1,407	1,414	1,484	1,467	1,373	1,277	1,232
Below Normal	1,294	1,305	1,326	1,351	1,413	1,438	1,390	1,383	1,359	1,268	1,175	1,133
Dry	1,095	1,094	1,106	1,122	1,156	1,188	1,154	1,132	1,088	997	914	871
Critical	624	624	639	646	662	657	603	555	527	477	432	409
Average All Years	1,133	1,142	1,180	1,237	1,306	1,349	1,338	1,374	1,381	1,300	1,209	1,159
No Action compared to Alternative 1 (TAF)												
Wet	0	0	0	0	0	0	0	0	0	0	0	0
Above Normal	0	0	0	0	0	0	0	0	0	0	0	0
Below Normal	0	0	0	0	0	0	0	0	0	0	0	0
Dry	0	0	0	0	0	0	0	0	0	0	0	0
Critical	0	0	0	0	0	0	0	0	1	0	0	0
Average All Years	0	0	0	0	0	0	0	0	0	0	0	0
No Action compared to Alternative 1 (%)												
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Below Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Critical	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Key:
% = percent
TAF = thousand acre-feet

Table 4-19. Changes in Stanislaus River Flow Downstream from Goodwin Dam Under Alternative 1 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (cfs)												
Wet	789	435	694	1,139	1,273	1,762	1,538	1,642	1,129	617	549	583
Above Normal	706	200	204	229	273	414	1,244	1,085	717	354	286	257
Below Normal	740	209	211	237	316	320	1,262	1,099	448	275	285	254
Dry	698	210	215	236	274	200	872	797	397	279	283	249
Critical	622	200	218	217	265	261	627	607	350	254	236	212
Average All Years	723	278	365	518	595	754	1,158	1,123	680	394	361	351
Alternative 1 (cfs)												
Wet	789	435	694	1,139	1,273	1,762	1,538	1,642	1,129	617	549	583
Above Normal	706	200	204	229	273	414	1,244	1,085	717	354	286	257
Below Normal	740	209	211	237	316	320	1,262	1,099	448	275	285	254
Dry	698	210	215	236	274	200	872	797	397	279	283	249
Critical	622	200	218	217	265	261	626	607	349	253	236	212
Average All Years	723	278	365	518	595	754	1,158	1,123	679	394	361	351
No Action compared to Alternative 1 (cfs)												
Wet	0	0	0	0	0	0	0	0	0	0	0	0
Above Normal	0	0	0	0	0	0	0	0	0	0	0	0
Below Normal	0	0	0	0	0	0	0	0	0	0	0	0
Dry	0	0	0	0	0	0	0	0	0	0	0	0
Critical	0	0	0	0	0	0	-1	0	-1	-1	0	0
Average All Years	0	0	0	0	0	0	0	0	-1	0	0	0
No Action compared to Alternative 1 (%)												
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Below Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Critical	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Key:
% = percent
cfs = cubic feet per second

San Luis Reservoir San Luis Reservoir is jointly operated by the CVP and the SWP, they each have a share of the total storage. San Luis Reservoir CVP and SWP storage is summarized in Tables 4-20 and 4-21. The elevation in San Luis Reservoir is based on the sum of the CVP and SWP volumes and is summarized in Table 4-22.

San Luis Reservoir CVP storage under Alternative 1 is similar to the No Action Alternative with increases of 0 to 2 percent in most months of most years but up to an increase of 4 percent in June of critical years.

San Luis Reservoir SWP storage under Alternative 1 is similar to the No Action Alternative with changes of less than 1 percent in all months of all year types.

San Luis elevation under Alternative 1 is similar to the No Action Alternative with changes of less than 1 percent in all months of all year types.

Table 4-20. Changes in San Luis Reservoir CVP Storage Under Alternative 1 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (TAF)												
Wet	234	352	523	652	778	884	810	661	518	309	195	204
Above Normal	232	377	547	648	733	823	724	544	360	163	109	125
Below Normal	239	357	533	641	698	749	662	496	299	221	166	207
Dry	239	345	510	639	711	751	691	562	389	311	209	223
Critical	266	334	460	582	634	629	579	485	332	258	217	229
Average All Years	240	353	516	636	723	786	714	570	405	267	184	200
Alternative 1 (TAF)												
Wet	235	355	525	654	780	886	812	663	521	312	198	207
Above Normal	235	381	551	651	736	826	727	547	363	165	109	125
Below Normal	241	360	536	645	700	751	665	500	305	225	168	209
Dry	242	348	514	643	715	754	696	570	399	319	213	229
Critical	269	339	467	592	646	640	592	499	347	266	222	229
Average All Years	243	356	520	641	727	790	718	576	412	272	187	203
No Action compared to Alternative 1 (TAF)												
Wet	1	3	2	3	2	2	2	2	3	3	3	2
Above Normal	2	4	5	2	2	3	3	3	3	2	0	0
Below Normal	2	3	3	4	2	2	3	4	6	4	2	2
Dry	3	2	3	4	4	4	5	7	10	8	4	6
Critical	3	5	7	10	11	12	13	14	15	8	5	0
Average All Years	2	3	4	4	4	4	5	6	7	5	3	2
No Action compared to Alternative 1 (%)												
Wet	1%	1%	0%	0%	0%	0%	0%	0%	1%	1%	2%	1%
Above Normal	1%	1%	1%	0%	0%	0%	0%	1%	1%	1%	0%	0%
Below Normal	1%	1%	1%	1%	0%	0%	0%	1%	2%	2%	1%	1%
Dry	1%	1%	1%	1%	1%	0%	1%	1%	3%	2%	2%	3%
Critical	1%	2%	2%	2%	2%	2%	2%	3%	4%	3%	2%	0%
Average All Years	1%	1%	1%	1%	1%	1%	1%	1%	2%	2%	2%	1%

Key:
% = percent
TAF = thousand acre-feet

Table 4-21. Changes in San Luis Reservoir SWP Storage Under Alternative 1 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (TAF)												
Wet	310	310	379	555	729	903	788	590	432	431	434	470
Above Normal	236	259	390	550	690	827	713	502	304	302	321	382
Below Normal	258	220	309	433	553	685	608	446	238	264	262	261
Dry	222	232	336	491	616	728	685	563	395	385	184	156
Critical	146	138	203	373	496	556	543	477	354	226	105	81
Average All Years	246	246	335	496	638	768	691	534	365	347	284	295
Alternative 1 (TAF)												
Wet	310	310	377	554	729	903	788	590	432	430	433	470
Above Normal	236	256	387	551	690	827	713	502	304	302	320	381
Below Normal	259	220	309	433	553	685	608	446	238	263	262	261
Dry	220	230	333	489	614	727	684	562	394	385	183	156
Critical	145	137	203	371	492	552	539	473	355	228	105	81
Average All Years	245	245	333	495	637	768	690	533	365	347	283	294
No Action compared to Alternative 1 (TAF)												
Wet	-1	0	-1	-1	0	0	0	0	0	-1	-1	-1
Above Normal	0	-3	-3	1	0	0	0	0	-1	-1	-1	-1
Below Normal	0	0	0	0	1	0	0	0	0	0	0	0
Dry	-2	-2	-2	-2	-2	-1	-1	-1	-1	0	0	0
Critical	-1	-2	0	-3	-4	-4	-4	-4	2	2	0	0
Average All Years	-1	-1	-1	-1	-1	-1	-1	-1	0	0	0	0
No Action compared to Alternative 1 (%)												
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	0%	-1%	-1%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Below Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dry	-1%	-1%	-1%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Critical	-1%	-1%	0%	-1%	-1%	-1%	-1%	-1%	0%	1%	0%	0%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Key:
% = percent
TAF = thousand acre-feet

Table 4-22. Changes in San Luis Reservoir Surface Elevation Under Alternative 1 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (feet)												
Wet	399	413	440	471	499	523	507	476	445	422	410	416
Above Normal	390	410	443	469	491	511	493	456	415	390	386	397
Below Normal	393	405	435	459	475	492	477	445	398	391	384	390
Dry	390	405	435	465	483	496	487	464	427	418	379	377
Critical	382	391	414	446	463	468	462	446	416	392	366	365
Average All Years	392	406	435	464	485	503	489	461	425	407	389	393
Alternative 1 (feet)												
Wet	399	413	441	471	499	523	507	476	445	423	410	416
Above Normal	390	411	443	470	491	511	493	456	415	390	386	397
Below Normal	394	405	435	459	476	493	478	446	399	391	384	390
Dry	390	405	435	465	483	497	488	464	428	419	379	378
Critical	383	391	415	447	464	469	463	448	418	393	367	365
Average All Years	392	407	435	464	486	503	490	462	426	408	389	393
No Action compared to Alternative 1 (feet)												
Wet	0	0	0	0	0	0	0	0	0	0	0	0
Above Normal	0	0	0	0	0	0	0	0	0	0	0	0
Below Normal	0	0	0	0	0	0	0	0	1	0	0	0
Dry	0	0	0	0	0	0	0	1	1	1	0	1
Critical	0	1	1	1	1	1	1	1	2	2	1	0
Average All Years	0	0	0	0	0	0	0	0	1	1	0	0
No Action compared to Alternative 1 (%)[1]												
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Below Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Critical	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Note:
[1] Percent change estimated based on the change in active storage elevation (i.e., top of dead pool elevation to top of conservation pool elevation) not the change in total absolute elevation
Key:
% = percent

Changes in Delta Conditions

San Joaquin River Delta Inflow The San Joaquin River flow at Vernalis was selected to represent the San Joaquin River inflow to the Sacramento-San Joaquin Delta and is summarized in Table 4-23.

The San Joaquin River flow at Vernalis under Alternative 1 is similar to the No Action Alternative with changes of less than 1 percent in all months of all year types.

Table 4-23. Changes in San Joaquin River Flows at Vernalis Under Alternative 1 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (cfs)												
Wet	3,041	3,335	5,580	10,083	12,545	14,021	13,228	11,380	8,751	5,260	2,788	3,061
Above Normal	2,386	2,213	3,279	4,375	6,150	6,704	7,694	5,514	3,482	2,016	1,765	2,214
Below Normal	2,869	2,552	2,414	2,701	4,590	4,249	5,597	3,698	2,029	1,491	1,576	1,997
Dry	2,554	2,344	2,084	2,295	3,120	3,599	4,311	3,240	1,729	1,221	1,343	1,762
Critical	2,196	1,975	1,842	1,757	2,223	2,198	2,129	1,848	1,184	933	983	1,395
Average All Years	2,672	2,611	3,391	5,070	6,655	7,278	7,528	6,039	4,194	2,622	1,847	2,223
Alternative 1 (cfs)												
Wet	3,041	3,335	5,580	10,083	12,545	14,021	13,228	11,380	8,751	5,260	2,788	3,061
Above Normal	2,386	2,213	3,279	4,375	6,151	6,704	7,695	5,514	3,482	2,016	1,765	2,214
Below Normal	2,869	2,552	2,414	2,701	4,591	4,249	5,597	3,698	2,029	1,491	1,576	1,997
Dry	2,554	2,344	2,084	2,295	3,120	3,599	4,311	3,240	1,729	1,221	1,343	1,762
Critical	2,196	1,975	1,842	1,757	2,223	2,198	2,128	1,847	1,183	932	982	1,395
Average All Years	2,672	2,611	3,391	5,070	6,655	7,278	7,528	6,039	4,194	2,621	1,847	2,223
No Action compared to Alternative 1 (cfs)												
Wet	0	0	0	0	0	0	0	0	0	0	0	0
Above Normal	0	0	0	0	1	0	1	0	0	0	0	0
Below Normal	0	0	0	0	1	0	0	0	0	0	0	0
Dry	0	0	0	0	0	0	0	0	0	0	0	0
Critical	0	0	0	0	0	0	-1	-1	-1	-1	-1	0
Average All Years	0	0	0	0	0	0	0	0	0	-1	0	0
No Action compared to Alternative 1 (%)												
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Below Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Critical	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Key:
% = percent
cfs = cubic feet per second

Sacramento River Delta Inflow The Sacramento River flow at Freeport was selected to represent the Sacramento River inflow to the Sacramento-San Joaquin Delta and is summarized in Table 4-24.

The Sacramento River flow at Freeport under Alternative 1 is similar to the No Action Alternative with changes of less than 1 percent in all months of all year types.

Table 4-24. Changes in Sacramento River Flow at Freeport Under Alternative 1 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (cfs)												
Wet	13,044	20,443	36,311	49,134	56,402	48,167	35,405	29,889	20,143	20,340	16,057	27,926
Above Normal	10,198	17,154	24,532	38,476	46,555	40,701	24,151	16,803	13,676	23,093	16,887	21,166
Below Normal	12,209	15,828	15,772	18,275	30,217	18,597	14,072	12,614	12,955	22,230	15,653	12,113
Dry	10,200	12,772	13,617	17,174	23,405	21,310	14,907	11,791	12,985	17,454	10,500	9,981
Critical	8,103	8,465	11,077	14,101	15,881	12,532	10,341	8,367	9,833	10,892	8,758	7,214
Average All Years	11,064	15,679	22,460	30,383	37,350	31,251	22,092	17,933	14,899	18,943	13,711	17,325
Alternative 1 (cfs)												
Wet	13,034	20,455	36,289	49,132	56,401	48,153	35,404	29,875	20,143	20,332	16,057	27,907
Above Normal	10,179	17,221	24,498	38,465	46,554	40,706	24,154	16,806	13,681	23,093	16,875	21,154
Below Normal	12,172	15,840	15,769	18,275	30,208	18,590	14,072	12,635	12,954	22,158	15,600	12,092
Dry	10,198	12,765	13,639	17,179	23,422	21,305	14,910	11,791	12,986	17,347	10,400	9,987
Critical	8,053	8,482	11,087	14,104	15,830	12,532	10,341	8,368	9,941	10,755	8,659	7,151
Average All Years	11,045	15,695	22,455	30,382	37,345	31,245	22,093	17,932	14,916	18,885	13,663	17,307
No Action compared to Alternative 1 (cfs)												
Wet	-10	12	-22	-2	-1	-14	-1	-14	0	-8	0	-19
Above Normal	-19	67	-34	-11	-1	5	3	3	5	0	-12	-12
Below Normal	-37	12	-3	0	-9	-7	0	21	-1	-72	-53	-21
Dry	-2	-7	22	5	17	-5	3	0	1	-107	-100	6
Critical	-50	17	10	3	-51	0	0	1	108	-137	-99	-63
Average All Years	-19	16	-5	-1	-5	-6	1	-1	17	-58	-48	-18
No Action compared to Alternative 1 (%)												
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Below Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	-1%	-1%	0%
Critical	-1%	0%	0%	0%	0%	0%	0%	0%	1%	-1%	-1%	-1%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Key:
% = percent
cfs = cubic feet per second

Sacramento-San Joaquin Delta Outflow The Sacramento-San Joaquin Delta outflow is summarized in Table 4-25.

The Sacramento-San Joaquin Delta outflow under Alternative 1 is similar to the No Action Alternative with changes of less than 1 percent in all months of all year types.

Table 4-25 Changes in Delta Outflow Under Alternative 1 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (cfs)												
Wet	8,445	17,135	47,370	89,535	101,936	81,603	55,719	38,900	18,814	10,606	4,430	19,051
Above Normal	5,404	12,250	24,302	49,849	67,107	52,281	32,579	19,505	8,147	10,852	4,082	11,130
Below Normal	7,669	10,903	9,449	17,479	36,356	17,934	17,060	12,805	7,484	8,246	4,129	3,550
Dry	5,539	7,902	7,600	15,914	25,698	22,720	16,749	11,073	7,229	5,144	4,178	3,194
Critical	4,126	4,980	6,727	11,691	15,322	12,160	9,391	6,693	5,845	4,053	3,786	3,000
Average All Years	6,518	11,494	22,978	44,229	56,347	43,889	30,580	20,824	10,880	8,037	4,179	9,499
Alternative 1 (cfs)												
Wet	8,443	17,139	47,374	89,526	101,912	81,598	55,716	38,886	18,814	10,603	4,430	19,051
Above Normal	5,404	12,346	24,276	49,823	67,091	52,291	32,582	19,507	8,152	10,852	4,082	11,130
Below Normal	7,669	10,904	9,446	17,479	36,401	17,926	17,061	12,827	7,483	8,226	4,127	3,543
Dry	5,539	7,911	7,606	15,912	25,720	22,716	16,752	11,072	7,229	5,144	4,191	3,198
Critical	4,125	4,980	6,723	11,703	15,269	12,160	9,391	6,693	5,844	4,052	3,766	3,000
Average All Years	6,517	11,512	22,976	44,223	56,341	43,887	30,580	20,823	10,880	8,033	4,179	9,499
No Action compared to Alternative 1 (cfs)												
Wet	-2	4	4	-9	-24	-5	-3	-14	0	-3	0	0
Above Normal	0	96	-26	-26	-16	10	3	2	5	0	0	0
Below Normal	0	1	-3	0	45	-8	1	22	-1	-20	-2	-7
Dry	0	9	6	-2	22	-4	3	-1	0	0	13	4
Critical	-1	0	-4	12	-53	0	0	0	-1	-1	-20	0
Average All Years	-1	18	-2	-6	-6	-2	0	-1	0	-4	0	0
No Action compared to Alternative 1 (%)												
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Below Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Critical	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-1%	0%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Key:
% = percent
cfs = cubic feet per second

Old and Middle River Flow The OMR condition in the Sacramento-San Joaquin Delta outflow is summarized in Table 4-26.

OMR under Alternative 1 is similar to the No Action Alternative in all months and year types with reductions of 0 to 3 percent except in June of critical years where there is an increase of 6 percent. The average is from a single critical year, 1992 with a change in OMR from -1943 cfs in the No Action to -3140 cfs in Alternative 1. The change in OMR was mainly driven by a single month increase in Banks pumping, which in turn was driven by a slight decrease in SWP San Luis storage. This is a unique occurrence without large consequences that may not have occurred under shorter term real time operation decisions and is not expected to occur on a regular basis. CalSim II modifies exports as required in order to maintain the final OMR within regulatory limits.

Table 4-26. Changes in OMR Conditions Under Alternative 1 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (cfs)												
Wet	-5,951	-7,307	-5,524	-1,904	-2,002	-1,613	3,109	2,002	-4,331	-8,978	-10,576	-9,279
Above Normal	-5,597	-6,892	-6,821	-3,501	-3,371	-4,176	1,189	408	-4,525	-9,238	-10,834	-9,539
Below Normal	-5,714	-6,856	-7,653	-4,379	-3,499	-4,036	157	-327	-3,445	-10,570	-9,719	-8,150
Dry	-5,507	-6,045	-6,697	-4,620	-3,705	-3,079	-675	-925	-3,405	-9,211	-4,766	-6,299
Critical	-4,670	-4,396	-4,948	-4,339	-2,969	-1,782	-797	-982	-1,608	-4,015	-3,372	-3,794
Average All Years	-5,567	-6,447	-6,217	-3,508	-2,977	-2,727	914	286	-3,619	-8,564	-8,031	-7,639
Alternative 1 (cfs)												
Wet	-5,944	-7,313	-5,524	-1,904	-1,992	-1,600	3,109	2,002	-4,331	-8,974	-10,576	-9,261
Above Normal	-5,578	-6,871	-6,821	-3,491	-3,352	-4,174	1,189	408	-4,525	-9,238	-10,823	-9,534
Below Normal	-5,680	-6,867	-7,653	-4,379	-3,458	-4,035	156	-327	-3,445	-10,523	-9,671	-8,138
Dry	-5,504	-6,032	-6,712	-4,622	-3,703	-3,078	-675	-925	-3,405	-9,117	-4,666	-6,306
Critical	-4,647	-4,412	-4,959	-4,331	-2,970	-1,782	-797	-983	-1,708	-3,890	-3,303	-3,740
Average All Years	-5,553	-6,446	-6,222	-3,506	-2,965	-2,722	914	286	-3,633	-8,514	-7,988	-7,625
No Action compared to Alternative 1 (cfs)												
Wet	7	-6	0	0	10	13	0	0	0	4	0	18
Above Normal	19	21	0	10	19	2	0	0	0	0	11	5
Below Normal	34	-11	0	0	41	1	-1	0	0	47	48	12
Dry	3	13	-15	-2	2	1	0	0	0	94	100	-7
Critical	23	-16	-11	8	-1	0	0	-1	-100	125	69	54
Average All Years	14	1	-5	2	12	5	0	0	-14	50	43	14
No Action compared to Alternative 1 (%)												
Wet	0%	0%	0%	0%	0%	-1%	0%	0%	0%	0%	0%	0%
Above Normal	0%	0%	0%	0%	-1%	0%	0%	0%	0%	0%	0%	0%
Below Normal	-1%	0%	0%	0%	-1%	0%	0%	0%	0%	0%	0%	0%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	-1%	-2%	0%
Critical	0%	0%	0%	0%	0%	0%	0%	0%	6%	-3%	-2%	-1%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	-1%	-1%	0%

Key:
% = percent
cfs = cubic feet per second
OMR = Old and Middle River

Changes in CVP and SWP Exports

Jones Pumping Plant (CVP Exports) Jones Pumping Plant is the major CVP delta export facility. Exports at Jones Pumping Plant under Alternative 1 as compared to the No Action Alternative are summarized in Table 4-27.

Exports at Jones Pumping Plant under Alternative 1 are similar to the No Action with decreases of 0-3 percent, except in July and August of critical years where it is reduced by 7 percent.

Table 4-27. Changes in Exports at Jones Pumping Plant Under Alternative 1 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (cfs)												
Wet	3,388	3,612	4,042	3,571	3,986	3,748	1,606	1,549	3,751	4,048	4,578	4,083
Above Normal	3,221	3,857	3,754	2,695	2,873	3,512	1,104	898	2,794	3,202	4,478	3,875
Below Normal	3,595	3,603	4,104	3,192	2,841	2,831	1,009	819	1,932	4,239	3,811	3,979
Dry	3,263	3,263	3,735	3,227	2,797	2,329	1,211	992	1,549	3,373	2,569	3,334
Critical	2,792	2,396	2,816	2,668	1,912	1,337	863	827	608	2,068	2,415	2,664
Average All Years	3,272	3,387	3,750	3,165	3,063	2,889	1,241	1,106	2,358	3,485	3,653	3,646
Alternative 1 (cfs)												
Wet	3,387	3,633	4,033	3,570	3,974	3,736	1,605	1,549	3,751	4,049	4,578	4,064
Above Normal	3,221	3,882	3,754	2,647	2,867	3,504	1,104	898	2,795	3,202	4,465	3,869
Below Normal	3,560	3,610	4,103	3,192	2,785	2,827	1,009	819	1,932	4,188	3,800	3,971
Dry	3,265	3,253	3,742	3,228	2,793	2,310	1,209	993	1,539	3,288	2,499	3,352
Critical	2,774	2,430	2,840	2,699	1,929	1,336	862	827	601	1,924	2,331	2,577
Average All Years	3,264	3,401	3,753	3,162	3,052	2,878	1,240	1,107	2,355	3,437	3,620	3,629
No Action compared to Alternative 1 (cfs)												
Wet	-1	20	-9	-1	-13	-12	-1	0	0	2	0	-19
Above Normal	0	26	1	-49	-5	-8	0	0	1	0	-12	-6
Below Normal	-36	7	0	0	-55	-4	0	0	0	-51	-11	-8
Dry	1	-10	8	1	-5	-19	-2	1	-10	-85	-70	18
Critical	-19	34	25	31	17	-1	-1	0	-7	-144	-83	-87
Average All Years	-7	14	3	-3	-11	-10	-1	0	-3	-48	-33	-16
No Action compared to Alternative 1 (%)												
Wet	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	0%	1%	0%	-2%	0%	0%	0%	0%	0%	0%	0%	0%
Below Normal	-1%	0%	0%	0%	-2%	0%	0%	0%	0%	-1%	0%	0%
Dry	0%	0%	0%	0%	0%	-1%	0%	0%	-1%	-3%	-3%	1%
Critical	-1%	1%	1%	1%	1%	0%	0%	0%	-1%	-7%	-3%	-3%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	-1%	-1%	0%

Key:
% = percent
cfs = cubic feet per second

Banks Pumping Plant (SWP Exports) Banks Pumping plant is the major SWP Delta export facility. Exports at Banks Pumping Plant under Alternative 1 as compared to the No Action Alternative are summarized in Table 4-28.

Banks export under Alternative 1 is similar to the No Action Alternative in all months and year types with reduction of 0 to 2 percent except in June of critical years where it increases by 21 percent. The average is from a single critical year, 1992, with a change in Banks exports from 448 in the No Action to 1743 in Alternative 1. The change in Banks exports was mainly driven by a slight decrease in SWP San Luis storage that had accumulated over several months. This is unique occurrence without large consequences that may not have occurred under shorter term real time operation decisions and is not expected to occur on a regular basis.

Table 4-28. Changes in Exports at Banks Pumping Plant Under Alternative 1 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (cfs)												
Wet	3,287	4,743	5,101	4,768	5,634	5,972	1,817	1,822	3,790	6,719	7,102	6,538
Above Normal	2,932	3,767	5,324	3,670	4,444	4,562	1,089	814	2,503	6,364	7,004	6,680
Below Normal	2,788	4,068	5,476	3,099	3,477	3,700	1,238	814	1,577	6,472	6,415	5,105
Dry	2,812	3,464	4,550	3,144	2,975	2,846	1,366	1,040	1,766	5,755	2,263	3,649
Critical	2,290	2,434	3,359	3,032	2,555	1,581	698	628	548	1,295	675	1,397
Average All Years	2,902	3,848	4,797	3,720	4,057	4,038	1,350	1,161	2,321	5,601	4,873	4,912
Alternative 1 (cfs)												
Wet	3,280	4,730	5,111	4,769	5,635	5,971	1,818	1,822	3,790	6,712	7,102	6,538
Above Normal	2,911	3,719	5,324	3,707	4,430	4,568	1,089	814	2,501	6,363	7,004	6,680
Below Normal	2,786	4,073	5,477	3,098	3,487	3,702	1,238	813	1,577	6,472	6,374	5,099
Dry	2,808	3,459	4,558	3,145	2,977	2,862	1,367	1,039	1,776	5,737	2,224	3,639
Critical	2,285	2,418	3,346	2,992	2,539	1,581	698	628	662	1,303	684	1,426
Average All Years	2,894	3,833	4,801	3,720	4,055	4,043	1,351	1,161	2,340	5,595	4,859	4,912
No Action compared to Alternative 1 (cfs)												
Wet	-7	-13	9	1	2	-1	0	0	0	-7	0	0
Above Normal	-21	-48	-1	38	-14	6	0	0	-2	0	0	0
Below Normal	-2	5	0	0	10	2	1	0	0	0	-41	-6
Dry	-4	-5	8	1	2	17	1	-1	10	-18	-39	-10
Critical	-6	-16	-12	-40	-16	0	0	0	114	8	9	28
Average All Years	-8	-15	3	1	-2	5	0	0	19	-5	-14	1
No Action compared to Alternative 1 (%)												
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	-1%	-1%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%
Below Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-1%	0%
Dry	0%	0%	0%	0%	0%	1%	0%	0%	1%	0%	-2%	0%
Critical	0%	-1%	0%	-1%	-1%	0%	0%	0%	21%	1%	1%	2%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%

Key:
% = percent
cfs = cubic feet per second

Changes in CVP and SWP Water Supply Delivery The CVP and SWP both deliver water to a variety of customers under different contractual terms. The comparison of changes for CVP and SWP water supply delivery is divided into four categories, including CVP North-of-Delta (NOD), CVP South-of-Delta (SOD), CVP Eastside and SWP.

CVP Delivery North of the Delta CVP NOD water deliveries are summarized in Table 4-29. CVP NOD delivery under Alternative 1 is similar to the No Action Alternative with less than a 5 percent change in all year types for all customers, except critical years for CVP Agricultural Water Service Contractors where it is reduced by 10 percent (23 TAF to 21 TAF).

Table 4-29. Changes in CVP North-of-Delta Water Deliveries Under Alternative 1 as Compared to the No Action Alternative, by Sacramento Water Year Type

Alternative/Comparison	Wet	Above Normal	Below Normal	Dry	Critical	Average All Years
CVP Agricultural Water Service Contractors						
No Action (TAF)	305	263	167	89	23	186
Alternative 1 (TAF)	304	262	165	84	21	184
No Action Compared to Alternative 1 (TAF)	-1	-1	-2	-4	-2	-2
No Action Compared to Alternative 1 (%)	0%	0%	-1%	-5%	-10%	-1%
CVP M&I (including Contra Costa)						
No Action (TAF)	386	383	333	292	245	335
Alternative 1 (TAF)	386	381	333	290	241	333
No Action Compared to Alternative 1 (TAF)	0	-1	0	-2	-4	-1
No Action Compared to Alternative 1 (%)	0%	0%	0%	-1%	-2%	0%
CVP Sacramento River Settlement Contractors						
No Action (TAF)	1,844	1,865	1,890	1,915	1,748	1,857
Alternative 1 (TAF)	1,844	1,865	1,890	1,915	1,744	1,856
No Action Compared to Alternative 1 (TAF)	0	0	0	0	-4	0
No Action Compared to Alternative 1 (%)	0%	0%	0%	0%	0%	0%
CVP Refuge Level 2 Deliveries						
No Action (TAF)	88	85	86	85	63	83
Alternative 1 (TAF)	88	85	86	85	62	83
No Action Compared to Alternative 1 (TAF)	0	0	0	0	-1	0
No Action Compared to Alternative 1 (%)	0%	0%	0%	0%	-1%	0%
Total CVP NOD Deliveries						
No Action (TAF)	2,622	2,596	2,477	2,381	2,079	2,460
Alternative 1 (TAF)	2,621	2,593	2,475	2,375	2,068	2,456
No Action Compared to Alternative 1 (TAF)	-1	-2	-3	-7	-11	-4
No Action Compared to Alternative 1 (%)	0%	0%	0%	0%	-1%	0%

Key:
% = percent
CVP = Central Valley Project
M&I – municipal and industrial
NOD = North-of-Delta
TAF = thousand acre-feet

CVP Delivery South of the Delta CVP SOD water deliveries are summarized in Table 4-30.

CVP SOD water deliveries under Alternative 1 are similar to the No Action Alternative with less than a 3 percent change or less in all year types for all customers, except critical years for CVP Agricultural Water Service Contractors where it is reduced by 7 percent (137 TAF to 127 TAF).

Table 4-30. Changes in CVP South-of-Delta Water Deliveries Under Alternative 1 as Compared to the No Action Alternative, by Sacramento Water Year Type

Alternative/Comparison	Wet	Above Normal	Below Normal	Dry	Critical	Average All Years
CVP Agricultural Water Service Contractors						
No Action (TAF)	1,316	885	752	480	137	795
Alternative 1 (TAF)	1,313	884	742	463	127	787
No Action Compared to Alternative 1 (TAF)	-3	-1	-10	-17	-10	-8
No Action Compared to Alternative 1 (%)	0%	0%	-1%	-3%	-7%	-1%
CVP M&I						
No Action (TAF)	132	112	114	104	85	113
Alternative 1 (TAF)	132	112	114	103	83	112
No Action Compared to Alternative 1 (TAF)	0	0	0	-1	-2	-1
No Action Compared to Alternative 1 (%)	0%	0%	0%	-1%	-2%	-1%
San Joaquin River Exchange Contractors						
No Action (TAF)	874	870	858	871	752	853
Alternative 1 (TAF)	874	870	858	871	752	853
No Action Compared to Alternative 1 (TAF)	0	0	0	0	0	0
No Action Compared to Alternative 1 (%)	0%	0%	0%	0%	0%	0%
CVP Refuge Level 2 Deliveries						
No Action	280	276	277	276	249	273
Alternative 1	280	276	277	276	249	273
No Action Compared to Alternative 1 (TAF)	0	0	0	0	0	0
No Action Compared to Alternative 1 (%)	0%	0%	0%	0%	0%	0%
Total CVP SOD Deliveries						
No Action (TAF)	2,601	2,143	2,001	1,729	1,223	2,034
Alternative 1 (TAF)	2,598	2,142	1,991	1,712	1,211	2,025
No Action Compared to Alternative 1 (TAF)	-4	-1	-10	-18	-11	-9
No Action Compared to Alternative 1 (%)	0%	0%	-1%	-1%	-1%	0%

Key:
% = percent
CVP = Central Valley Project
SOD = South-of-Delta
TAF = thousand acre-feet

CVP Eastside Delivery CVP Eastside water deliveries are summarized in Table 4-31.

CVP Eastside water deliveries under Alternative 1 are similar to the No Action Alternative with changes to all contractors in all year types of less than 1 percent.

Table 4-31. Changes in CVP Eastside Water Deliveries Under Alternative 1 as Compared to the No Action Alternative, by Sacramento Water Year Type

Alternative/Comparison	Wet	Above Normal	Below Normal	Dry	Critical	Average All Years
Water Rights						
No Action	505	518	532	532	443	508
Alternative 1	505	518	532	532	443	508
No Action Compared to Alternative 1 (TAF)	0	0	0	0	0	0
No Action Compared to Alternative 1 (%)	0%	0%	0%	0%	0%	0%
CVP Water Service Contracts						
No Action	146	116	117	86	12	103
Alternative 1	146	116	117	86	12	103
No Action Compared to Alternative 1 (TAF)	0	0	0	0	0	0
No Action Compared to Alternative 1 (%)	0%	0%	0%	0%	0%	0%
Total Eastside Deliveries						
No Action	651	634	649	618	454	611
Alternative 1	651	634	649	618	455	612
No Action Compared to Alternative 1 (TAF)	0	0	0	0	0	0
No Action Compared to Alternative 1 (%)	0%	0%	0%	0%	0%	0%

Key:
% = percent
CVP = Central Valley Project
TAF = thousand acre-feet

CVP Total Water Delivery CVP Total water deliveries are summarized in Table 4-32.

CVP total water deliveries under Alternative 1 are similar to the No Action Alternative with changes to all contractors in all year types less than 1 percent.

Table 4-32. Changes in CVP Total Water Deliveries Under Alternative 1 as Compared to the No Action Alternative, by Sacramento Water Year Type

Alternative/Comparison	Wet	Above Normal	Below Normal	Dry	Critical	Average All Years
All CVP Deliveries						
No Action	5,875	5,373	5,128	4,729	3,756	5,105
Alternative 1	5,870	5,369	5,115	4,705	3,734	5,093
No Action Compared to Alternative 1 (TAF)	-4	-4	-13	-24	-22	-13
No Action Compared to Alternative 1 (%)	0%	0%	0%	-1%	-1%	0%

Key:
% = percent
CVP = Central Valley Project
TAF = thousand acre-feet

SWP Table A and Article 21 Delivery SWP SOD water deliveries are summarized in Table 4-33.

SWP total water deliveries under Alternative 1 are similar to the No Action Alternative with changes to all contractors in all year types less than 3 percent.

Table 4-33. Changes in SWP Table A and Article 21 Water Deliveries Under Alternative 1 as Compared to the No Action Alternative, by Sacramento Water Year Type

Table A (TAF)						
Alternative/Comparison	**Wet**	**Above Normal**	**Below Normal**	**Dry**	**Critical**	**Average All Years**
No Action	3,178	2,684	2,526	2,052	1,207	2,449
Alternative 1	3,181	2,683	2,527	2,053	1,211	2,451
No Action Compared to Alternative 1 (TAF)	2	0	1	2	4	2
No Action Compared to Alternative 1 (%)	0%	0%	0%	0%	0%	0%
Article 21 (TAF)						
Alternative/Comparison	**Wet**	**Above Normal**	**Below Normal**	**Dry**	**Critical**	**Average All Years**
No Action	76	77	21	25	10	46
Alternative 1	74	77	21	25	10	46
No Action Compared to Alternative 1 (TAF)	-2	0	0	0	0	0
No Action Compared to Alternative 1 (%)	-3%	0%	0%	0%	0%	0%

Key:
% = percent
SWP = State Water Project
TAF = thousand acre-feet

Trinity River Record of Decision Flow Rescheduling Alternative (Alternative 2)

Lower Klamath and Trinity River Region

Changes in CVP and SWP Reservoir Storage, Elevation and Downstream River Flows Lower Klamath and Trinity River Region is divided into two sub-regions for this analysis. The Trinity River watershed includes the Trinity River from the headwaters to Lewiston Reservoir downstream from Trinity Lake. The lower Klamath River from Trinity River Confluence to the Pacific Ocean includes the Trinity River from Lewiston Reservoir downstream to the confluence with the Klamath River and the Klamath River downstream from the confluence to the ocean.

Trinity River Watershed Changes in the release to the Trinity River at Lewiston would result in changes to Trinity Lake operations and the Lewiston diversion into the Sacramento River basin. Trinity Lake storage and elevation is summarized in Tables 4-34 and 4-35, the release from Lewiston Dam to the Trinity River is summarized in Table 4-36. Changes in Trinity River Diversion to Sacramento Basin at Lewiston Reservoir are summarized in Table 4-37.

Trinity Lake storage under Alternative 2 would be similar to the No Action Alternative, with 1 percent or less change in most months and year types—with the exceptions of 2 percent decreases in October of extremely wet years and in September of critically dry years, and increases of 2 percent in dry years and 2 percent to 4 percent in June, July and August of critically dry years. Trinity Lake elevation under Alternative 2 is similar to the No Action Alternative with 1 percent or less change in all months of all year types.

The Lewiston Dam release to the Trinity River under Alternative 2 shows reductions from 1 percent to 38 percent in May and June of all year types with the larger reductions in the drier years and increases from 12 percent to 132 percent in August and September with the larger increases in the drier years as compared to the No Action Alternative. These changes are due to the reshaping of the ROD flows to save water earlier in the year to be used for augmentation purposes later in the year if required with the project.

The Trinity River Diversion to Sacramento Basin at Lewiston Reservoir under Alternative 2 shows reductions of up to 11 percent in February of critical years and increases of up to 9 percent in February of normal years as compared to the No Action Alternative. These changes do not follow the same pattern as the changes in Lewiston release to the Trinity River because they are dependent on both Trinity Lake conditions and operations and Sacramento Basin operations.

Table 4-34. Changes in Trinity Lake Storage Under Alternative 2 as Compared to the No Action Alternative, by Trinity Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (TAF)												
Extremely Wet	1,197	1,258	1,399	1,618	1,839	1,998	2,208	2,300	2,236	2,105	1,993	1,850
Wet	1,373	1,393	1,507	1,621	1,806	1,952	2,114	2,090	2,018	1,896	1,752	1,606
Normal	1,322	1,324	1,346	1,415	1,529	1,669	1,843	1,773	1,689	1,534	1,386	1,276
Dry	1,096	1,089	1,113	1,127	1,189	1,292	1,403	1,361	1,302	1,159	1,005	901
Critically Dry	1,051	1,016	1,014	988	1,012	1,068	1,087	1,048	985	836	676	598
Average All Years	1,233	1,242	1,306	1,385	1,511	1,637	1,779	1,755	1,686	1,548	1,403	1,283
Alternative 2 (TAF)												
Extremely Wet	1,176	1,241	1,381	1,601	1,823	1,981	2,192	2,285	2,223	2,092	1,980	1,841
Wet	1,371	1,391	1,506	1,621	1,805	1,952	2,112	2,090	2,023	1,896	1,752	1,602
Normal	1,328	1,330	1,352	1,422	1,536	1,676	1,850	1,788	1,705	1,552	1,401	1,276
Dry	1,099	1,091	1,116	1,129	1,190	1,294	1,404	1,378	1,323	1,177	1,018	901
Critically Dry	1,052	1,014	1,013	986	1,011	1,066	1,085	1,061	1,013	867	690	585
Average All Years	1,232	1,241	1,305	1,384	1,510	1,636	1,778	1,762	1,698	1,558	1,409	1,279
No Action compared to Alternative 2 (TAF)												
Extremely Wet	-21	-18	-18	-18	-16	-17	-17	-16	-13	-13	-13	-8
Wet	-2	-2	-1	0	-2	0	-1	0	5	0	0	-4
Normal	6	7	7	8	8	8	7	16	17	18	15	1
Dry	2	2	2	2	2	2	2	17	21	17	13	0
Critically Dry	1	-2	-2	-2	-1	-2	-2	13	28	30	14	-14
Average All Years	-1	-1	-1	-1	-1	-1	-1	7	11	10	6	-4
No Action compared to Alternative 2 (%)												
Extremely Wet	-2%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	0%
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Normal	0%	1%	0%	1%	0%	0%	0%	1%	1%	1%	1%	0%
Dry	0%	0%	0%	0%	0%	0%	0%	1%	2%	1%	1%	0%
Critically Dry	0%	0%	0%	0%	0%	0%	0%	1%	3%	4%	2%	-2%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	1%	1%	0%	0%

Key:
% = percent
TAF = thousand acre-feet

Table 4-35. Changes in Trinity Lake Elevation Under Alternative 2 as Compared to the No Action Alternative, by Trinity Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (feet)												
Extremely Wet	2,268	2,275	2,289	2,311	2,328	2,340	2,355	2,360	2,356	2,347	2,340	2,330
Wet	2,286	2,289	2,299	2,309	2,325	2,336	2,348	2,346	2,341	2,332	2,322	2,310
Normal	2,283	2,283	2,285	2,292	2,302	2,314	2,328	2,323	2,316	2,303	2,291	2,281
Dry	2,254	2,253	2,256	2,258	2,265	2,278	2,290	2,286	2,281	2,268	2,251	2,238
Critically Dry	2,251	2,248	2,248	2,247	2,250	2,257	2,260	2,255	2,249	2,231	2,206	2,194
Average All Years	2,271	2,272	2,278	2,286	2,297	2,309	2,320	2,318	2,313	2,301	2,287	2,276
Alternative 2 (feet)												
Extremely Wet	2,265	2,272	2,287	2,309	2,327	2,339	2,353	2,359	2,355	2,347	2,339	2,329
Wet	2,286	2,288	2,299	2,308	2,324	2,336	2,348	2,346	2,341	2,332	2,322	2,310
Normal	2,283	2,284	2,286	2,293	2,303	2,315	2,328	2,324	2,317	2,305	2,292	2,281
Dry	2,254	2,253	2,256	2,258	2,265	2,278	2,290	2,288	2,283	2,270	2,252	2,238
Critically Dry	2,251	2,248	2,248	2,247	2,250	2,257	2,259	2,257	2,252	2,235	2,208	2,192
Average All Years	2,271	2,272	2,278	2,286	2,297	2,309	2,320	2,319	2,314	2,302	2,288	2,275
No Action compared to Alternative 2 (feet)												
Extremely Wet	-3	-3	-2	-2	-1	-1	-1	-1	-1	-1	-1	-1
Wet	0	0	0	0	0	0	0	0	0	0	0	0
Normal	1	1	1	1	1	1	1	1	1	2	1	0
Dry	0	0	0	0	0	0	0	2	2	2	1	0
Critically Dry	0	0	0	0	0	0	0	2	4	4	2	-2
Average All Years	0	0	0	0	0	0	0	1	1	1	1	-1
No Action compared to Alternative 2 (%)[1]												
Extremely Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Critically Dry	0%	0%	0%	0%	0%	0%	0%	0%	1%	1%	0%	0%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Note:
[1] Percent change estimated based on the change in active storage elevation (i.e., top of dead pool elevation to top of conservation pool elevation) not the change in total absolute elevation.

Key:
% = percent

Table 4-36. Changes in Trinity River Flow Below Lewiston Dam Under Alternative 2 as Compared to the No Action Alternative, by Trinity Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (cfs)												
Extremely Wet	373	796	930	1,264	1,525	2,458	1,042	4,570	4,626	1,241	450	450
Wet	373	300	1,023	1,175	915	510	481	4,687	2,862	1,102	450	450
Normal	373	300	300	300	385	302	477	4,189	2,120	1,102	450	450
Dry	337	286	300	300	300	300	543	2,848	847	481	450	450
Critically Dry	368	267	300	300	300	300	600	1,498	783	450	450	400
Average All Years	363	359	605	696	668	654	584	3,753	2,210	890	450	445
Alternative 2 (cfs)												
Extremely Wet	373	730	935	1,262	1,491	2,471	1,042	4,570	4,572	1,241	460	477
Wet	373	300	1,030	1,166	930	507	481	4,658	2,777	1,102	503	533
Normal	373	300	300	300	363	302	477	4,052	2,085	1,102	508	632
Dry	337	286	300	300	300	300	543	2,567	738	481	574	725
Critically Dry	352	267	300	300	300	300	600	1,243	487	450	699	926
Average All Years	362	350	608	693	664	655	584	3,618	2,109	890	538	637
No Action compared to Alternative 2 (cfs)												
Extremely Wet	0	-66	5	-2	-34	13	0	0	-54	0	10	27
Wet	0	0	6	-10	15	-3	0	-29	-85	0	53	83
Normal	0	0	0	0	-22	0	0	-137	-35	0	58	182
Dry	0	0	0	0	0	0	0	-281	-109	0	124	275
Critically Dry	-17	0	0	0	0	0	0	-255	-296	0	249	526
Average All Years	-2	-9	3	-3	-4	1	0	-135	-100	0	88	193
No Action compared to Alternative 2 (%)												
Extremely Wet	0%	-8%	1%	0%	-2%	1%	0%	0%	-1%	0%	2%	6%
Wet	0%	0%	1%	-1%	2%	-1%	0%	-1%	-3%	0%	12%	18%
Normal	0%	0%	0%	0%	-6%	0%	0%	-3%	-2%	0%	13%	40%
Dry	0%	0%	0%	0%	0%	0%	0%	-10%	-13%	0%	28%	61%
Critically Dry	-5%	0%	0%	0%	0%	0%	0%	-17%	-38%	0%	55%	132%
Average All Years	-1%	-2%	0%	0%	-1%	0%	0%	-4%	-5%	0%	20%	43%

Key:
% = percent
cfs = cubic feet per second

Table 4-37. Changes in Trinity River Diversion to Sacramento Basin at Lewiston Reservoir under Alternative 2 as Compared to the No Action Alternative, by Trinity Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (cfs)												
Extremely Wet	827	233	235	410	7	329	278	498	407	1,836	1,526	2,079
Wet	945	541	376	482	97	322	591	0	290	1,190	1,952	2,065
Normal	792	355	193	418	243	396	228	0	472	1,553	1,991	1,471
Dry	712	418	166	385	134	153	229	247	1,011	1,973	2,098	1,358
Critically Dry	598	609	132	748	168	157	426	378	736	2,028	2,178	949
Average All Years	802	439	241	464	131	276	367	172	575	1,640	1,965	1,648
Alternative 2 (cfs)												
Extremely Wet	803	252	233	410	7	329	278	480	417	1,846	1,513	1,974
Wet	927	552	350	482	103	306	606	0	293	1,275	1,895	2,048
Normal	783	345	197	402	265	396	234	0	489	1,526	1,992	1,518
Dry	662	422	162	394	134	157	229	277	1,058	2,025	2,044	1,305
Critically Dry	650	654	132	752	150	171	426	394	773	1,988	2,190	891
Average All Years	784	449	232	464	135	274	373	179	596	1,671	1,933	1,618
No Action compared to Alternative 2 (cfs)												
Extremely Wet	-24	19	-2	0	0	0	0	-18	10	9	-13	-104
Wet	-18	10	-26	0	6	-16	15	0	4	85	-57	-17
Normal	-9	-10	4	-16	22	0	5	0	16	-27	1	47
Dry	-50	4	-4	10	0	4	0	30	46	52	-54	-53
Critically Dry	53	44	0	4	-19	14	0	17	37	-40	12	-58
Average All Years	-17	10	-8	0	4	-2	6	7	22	31	-31	-30
No Action compared to Alternative 2 (%)												
Extremely Wet	-3%	8%	-1%	0%	0%	0%	0%	-4%	2%	1%	-1%	-5%
Wet	-2%	2%	-7%	0%	6%	-5%	3%	0%	1%	7%	-3%	-1%
Normal	-1%	-3%	2%	-4%	9%	0%	2%	0%	3%	-2%	0%	3%
Dry	-7%	1%	-3%	2%	0%	3%	0%	12%	5%	3%	-3%	-4%
Critically Dry	9%	7%	0%	1%	-11%	9%	0%	4%	5%	-2%	1%	-6%
Average All Years	-2%	2%	-4%	0%	3%	-1%	2%	4%	4%	2%	-2%	-2%

Key:
% = percent
cfs = cubic feet per second

Lower Klamath River from Trinity River Confluence to the Pacific Ocean Flow augmentation releases to the Trinity River under Alternative 2 (Table 4-38) would increase flows at the mouth of the Klamath River in August and September in all year types except extremely wet, from 1 percent in August of wet years to 69 percent in September of critically dry years. Decreased inflows occurred in all year types except in May of extremely wet and wet years (ranging from 1 percent to 4 percent), and in June for all year types except extremely wet (ranging from 1 percent to 9 percent). The increases in August and September are due to potential augmentation releases while the reductions in the other portion of the years are due to changes in Trinity Lake releases due to reshaping the ROD flows.

Table 4-38. Changes in the Klamath River near Klamath Under Alternative 2 as Compared to the No Action Alternative, by Trinity Water Year Type (1980-2003)

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (cfs)												
Extremely Wet	2,905	7,625	18,287	27,315	34,773	36,035	23,665	22,135	15,412	6,395	3,011	2,924
Wet	2,764	6,383	18,091	22,061	24,264	20,527	14,685	16,405	9,417	3,765	2,351	2,541
Normal	2,015	6,377	9,388	14,482	11,199	19,978	14,294	11,428	6,021	2,934	2,099	2,978
Dry	2,982	5,483	6,935	7,121	9,172	9,355	8,414	7,808	4,350	2,027	1,974	2,434
Critically Dry	2,476	2,518	3,525	4,859	5,172	7,102	5,632	5,861	3,017	1,706	1,787	2,680
Average All Years	2,765	5,989	12,706	16,514	18,934	18,689	13,566	13,559	8,122	3,455	2,283	2,622
Alternative 2 (cfs)												
Extremely Wet	2,905	7,625	18,287	27,315	34,773	36,035	23,665	22,135	15,412	6,395	3,011	2,924
Wet	2,764	6,383	18,091	22,061	24,264	20,527	14,685	16,405	9,417	3,765	2,351	2,541
Normal	2,015	6,377	9,388	14,482	11,199	19,978	14,294	11,428	6,021	2,934	2,099	2,978
Dry	2,982	5,483	6,935	7,121	9,172	9,355	8,414	7,808	4,350	2,027	1,974	2,434
Critically Dry	2,476	2,518	3,525	4,859	5,172	7,102	5,632	5,861	3,017	1,706	1,787	2,680
Average All Years	2,765	5,989	12,706	16,514	18,934	18,689	13,566	13,559	8,122	3,455	2,283	2,622
No Action compared to Alternative 2 (cfs)												
Extremely Wet	0	0	13	0	-93	0	0	0	-54	0	0	3
Wet	0	0	15	0	0	0	0	-31	-88	0	31	33
Normal	0	0	0	0	0	0	0	-137	-35	0	247	914
Dry	0	0	0	0	0	0	0	-292	-92	0	174	466
Critically Dry	0	0	0	0	0	0	0	-255	-296	0	339	1,095
Average All Years	0	0	7	0	-16	0	0	-130	-96	0	112	316
No Action compared to Alternative 2 (%)												
Extremely Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Wet	0%	0%	0%	0%	0%	0%	0%	0%	-1%	0%	1%	1%
Normal	0%	0%	0%	0%	0%	0%	0%	-1%	-1%	0%	13%	44%
Dry	0%	0%	0%	0%	0%	0%	0%	-4%	-2%	0%	10%	24%
Critically Dry	0%	0%	0%	0%	0%	0%	0%	-4%	-9%	0%	23%	69%
Average All Years	0%	0%	0%	0%	0%	0%	0%	-1%	-1%	0%	5%	14%

Key:
% = percent
cfs = cubic feet per second

Central Valley and Bay-Delta Region

Changes in CVP and SWP Reservoir Storage, Elevation and Downstream River Flows This section is organized geographically as follows:

- Clear Creek (Whiskeytown Lake, Clear Creek below Whiskeytown)
- Sacramento River (Shasta Lake, Sacramento River below Keswick, Flow Into the Yolo Bypass)
- Feather River (Lake Oroville, Feather River below Oroville and Thermalito Afterbay)
- American River (Folsom Lake, American River below Nimbus Dam)
- San Joaquin River (New Melones, Stanislaus River below Goodwin Dam)

Clear Creek Whiskeytown Lake storage is summarized in Table 4-39. Whiskeytown Lake storage under Alternative 2 is similar to the No Action Alternative with changes of less than or equal to 2 percent in all months and year types. As there are no modeled changes to Whiskeytown storage, Whiskeytown Lake elevations under Alternative 2 would also be similar to the No Action Alternative.

Flows in Clear Creek downstream from Whiskeytown Dam are summarized in Table 4-40. Flows in Clear Creek downstream from Whiskeytown Dam under Alternative 2 would be similar to the No Action Alternative with changes less than or equal to 1 percent in all months of all year types.

Table 4-39. Changes in Whiskeytown Lake Storage Under Alternative 2 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (TAF)												
Wet	217	206	206	206	207	218	240	238	240	240	240	235
Above Normal	211	202	205	206	206	217	240	239	239	240	240	235
Below Normal	217	206	205	206	206	217	240	236	240	240	240	235
Dry	215	205	205	204	205	217	240	239	240	240	240	235
Critical	208	200	199	202	204	216	239	240	240	230	215	210
Average All Years	214	204	205	205	206	217	240	239	240	239	236	231
Alternative 2 (TAF)												
Wet	217	206	206	206	207	218	240	238	240	240	240	235
Above Normal	211	202	205	206	206	217	240	239	239	240	240	235
Below Normal	217	206	205	206	206	217	240	236	240	240	240	235
Dry	215	205	205	204	205	217	240	239	240	240	240	235
Critical	208	200	199	202	204	216	239	240	240	230	215	214
Average All Years	214	204	204	205	206	217	240	239	240	239	236	232
No Action compared to Alternative 2 (TAF)												
Wet	0	0	0	0	0	0	0	0	0	0	0	0
Above Normal	0	0	0	0	0	0	0	0	0	0	0	0
Below Normal	0	0	0	0	0	0	0	0	0	0	0	0
Dry	0	0	0	0	0	0	0	0	0	0	0	0
Critical	1	0	0	0	0	0	0	0	0	0	0	3
Average All Years	0	0	0	0	0	0	0	0	0	0	0	0
No Action compared to Alternative 2 (%)												
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Below Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Critical	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	2%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Key:
% = percent
TAF= thousand acre-feet

Table 4-40. Changes in Clear Creek Flows Below Whiskeytown Dam Under Alternative 2 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (cfs)												
Wet	200	200	200	309	249	207	200	277	200	85	85	150
Above Normal	181	182	188	192	196	196	196	277	200	85	85	150
Below Normal	195	195	195	195	195	195	195	274	191	85	85	150
Dry	178	184	188	190	190	190	190	267	183	85	85	150
Critical	163	167	167	167	167	167	167	214	111	85	85	133
Average All Years	185	188	190	225	207	194	191	265	181	85	85	148
Alternative 2 (cfs)												
Wet	200	200	200	309	249	207	200	277	200	85	85	150
Above Normal	181	182	188	192	196	196	196	277	200	85	85	150
Below Normal	195	195	195	195	195	195	195	274	191	85	85	150
Dry	178	184	188	190	190	190	190	267	183	85	85	150
Critical	163	167	167	167	167	167	167	214	111	85	85	133
Average All Years	185	188	190	225	207	194	191	265	181	85	85	148
No Action compared to Alternative 2 (cfs)												
Wet	0	0	0	0	0	0	0	0	0	0	0	0
Above Normal	0	0	0	0	0	0	0	0	0	0	0	0
Below Normal	0	0	0	0	0	0	0	0	0	0	0	0
Dry	0	0	0	0	0	0	0	0	0	0	0	0
Critical	0	0	0	0	0	0	0	0	0	0	0	0
Average All Years	0	0	0	0	0	0	0	0	0	0	0	0
No Action compared to Alternative 2 (%)												
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Below Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Critical	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Key:
% = percent
cfs = cubic feet per second

Sacramento River Shasta Lake storage and elevation are summarized in Tables 4-41 and 4-42. Sacramento River Flow Downstream from Keswick Dam is summarized in Table 4-43.

Shasta Lake storage under Alternative 2 is similar to the No Action Alternative with changes of less than or equal to 1 percent in all months and year types.

Shasta Lake elevation under Alternative 2 is similar to the No Action Alternative with changes of less than or equal to 1 percent in all months and year types.

Sacramento River Flow Downstream from Keswick Dam under Alternative 2 would be similar to the No Action Alternative with most months of all year types changing less than 1 percent, with the exception of a reduction of 3 percent in September of Critical years.

Table 4-41. Changes in Shasta Lake Storage Under Alternative 2 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (TAF)												
Wet	2,699	2,718	3,078	3,384	3,639	3,863	4,298	4,460	4,242	3,741	3,414	2,986
Above Normal	2,357	2,373	2,595	3,160	3,451	4,021	4,404	4,429	4,039	3,405	3,069	2,831
Below Normal	2,576	2,537	2,675	3,050	3,430	3,802	4,018	3,952	3,583	3,006	2,649	2,615
Dry	2,343	2,277	2,425	2,619	3,032	3,503	3,735	3,664	3,272	2,745	2,472	2,442
Critical	1,704	1,641	1,725	1,878	2,040	2,282	2,209	2,094	1,723	1,244	983	940
Average All Years	2,396	2,374	2,590	2,897	3,199	3,561	3,834	3,847	3,516	2,981	2,671	2,480
Alternative 2 (TAF)												
Wet	2,700	2,717	3,075	3,381	3,639	3,863	4,299	4,461	4,242	3,745	3,415	2,985
Above Normal	2,354	2,369	2,592	3,157	3,451	4,021	4,405	4,430	4,040	3,408	3,070	2,831
Below Normal	2,577	2,537	2,675	3,052	3,433	3,805	4,021	3,957	3,590	3,015	2,657	2,626
Dry	2,345	2,279	2,427	2,621	3,034	3,505	3,737	3,667	3,277	2,749	2,473	2,442
Critical	1,693	1,631	1,714	1,867	2,027	2,269	2,197	2,082	1,714	1,239	977	933
Average All Years	2,395	2,372	2,588	2,894	3,198	3,560	3,834	3,847	3,517	2,984	2,672	2,479
No Action compared to Alternative 2 (TAF)												
Wet	1	-1	-2	-3	0	0	0	0	0	5	1	-2
Above Normal	-3	-4	-3	-2	1	0	1	1	1	3	1	0
Below Normal	1	0	0	1	3	3	3	5	7	8	7	11
Dry	2	2	2	1	1	2	2	3	5	4	1	0
Critical	-11	-10	-11	-11	-13	-12	-12	-12	-10	-6	-6	-7
Average All Years	-1	-2	-2	-2	-1	-1	-1	0	1	3	1	0
No Action compared to Alternative 2 (%)												
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Below Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Critical	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	0%	-1%	-1%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Key:
% = percent
TAF = thousand acre-feet

Table 4-42. Changes in Shasta Lake Elevation Under Alternative 2 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (feet)												
Wet	992	993	1,010	1,024	1,034	1,042	1,058	1,064	1,056	1,038	1,025	1,006
Above Normal	968	968	983	1,013	1,026	1,048	1,062	1,063	1,049	1,025	1,010	1,000
Below Normal	987	985	992	1,009	1,025	1,040	1,048	1,045	1,031	1,007	990	989
Dry	970	968	976	987	1,007	1,027	1,037	1,034	1,019	995	982	980
Critical	929	925	931	941	953	970	966	959	936	900	877	873
Average All Years	973	972	983	999	1,013	1,029	1,039	1,039	1,025	1,001	986	977
Alternative 2 (feet)												
Wet	992	993	1,010	1,024	1,034	1,042	1,058	1,064	1,056	1,038	1,025	1,006
Above Normal	967	968	983	1,013	1,026	1,048	1,062	1,063	1,049	1,025	1,011	1,000
Below Normal	987	985	992	1,009	1,025	1,040	1,048	1,045	1,031	1,007	991	989
Dry	970	968	976	987	1,007	1,027	1,037	1,034	1,019	995	982	980
Critical	928	924	930	941	952	969	965	959	935	900	877	873
Average All Years	973	972	983	999	1,013	1,029	1,039	1,039	1,025	1,001	986	977
No Action compared to Alternative 2 (feet)												
Wet	0	0	0	0	0	0	0	0	0	0	0	0
Above Normal	0	0	0	0	0	0	0	0	0	0	0	0
Below Normal	0	0	0	0	0	0	0	0	0	0	0	1
Dry	0	0	0	0	0	0	0	0	0	0	0	0
Critical	-1	-1	-1	-1	-1	-1	-1	-1	0	0	0	-1
Average All Years	0	0	0	0	0	0	0	0	0	0	0	0
No Action compared to Alternative 2 (%)[1]												
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Below Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Critical	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Note:
[1] Percent change estimated based on the change in active storage elevation (i.e., top of dead pool elevation to top of conservation pool elevation) not the change in total absolute elevation.
Key:
% = percent

Table 4-43. Changes in Sacramento River Flow Downstream from Keswick Dam Under Alternative 2 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (cfs)												
Wet	6,818	8,363	11,973	17,356	19,393	16,389	9,092	8,198	10,102	13,287	10,378	13,022
Above Normal	6,075	7,101	7,675	7,991	16,094	7,942	6,236	7,332	11,099	14,708	10,512	9,046
Below Normal	6,653	6,916	4,069	3,777	6,831	4,216	5,631	7,238	11,103	14,132	10,963	5,299
Dry	5,992	6,421	3,860	4,070	3,581	3,828	4,809	6,916	11,036	13,306	9,226	4,580
Critical	4,978	4,601	3,634	3,409	3,563	3,382	6,285	6,445	9,713	11,908	8,895	4,437
Average All Years	6,207	6,944	7,032	8,768	11,012	8,450	6,720	7,363	10,565	13,428	9,980	8,040
Alternative 2 (cfs)												
Wet	6,804	8,403	11,984	17,367	19,345	16,370	9,093	8,191	10,106	13,290	10,376	13,012
Above Normal	6,121	7,152	7,653	7,982	16,040	7,952	6,237	7,334	11,104	14,707	10,541	9,061
Below Normal	6,656	6,911	4,066	3,777	6,838	4,216	5,632	7,245	11,104	14,156	10,981	5,296
Dry	6,000	6,434	3,864	4,061	3,584	3,826	4,810	6,919	11,039	13,319	9,208	4,581
Critical	4,971	4,629	3,648	3,410	3,569	3,382	6,284	6,440	9,697	11,845	8,911	4,283
Average All Years	6,211	6,972	7,035	8,768	10,990	8,445	6,720	7,362	10,566	13,426	9,984	8,017
No Action compared to Alternative 2 (cfs)												
Wet	-15	41	11	12	-49	-19	0	-7	5	3	-2	-10
Above Normal	45	50	-22	-10	-54	10	1	2	5	-1	29	15
Below Normal	3	-5	-3	0	7	0	1	7	1	24	18	-4
Dry	8	13	4	-8	4	-3	1	3	3	13	-18	1
Critical	-7	28	14	1	6	0	-1	-5	-16	-63	16	-154
Average All Years	4	27	3	0	-21	-5	0	-1	1	-2	4	-24
No Action compared to Alternative 2 (%)												
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	1%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Below Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Critical	0%	1%	0%	0%	0%	0%	0%	0%	0%	-1%	0%	-3%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Key:
% = percent
cfs = cubic feet per second

Feather River Lake Oroville storage and elevation are summarized in Tables 4-44 and 4-45. Flows in the Feather River downstream from the Thermalito Afterbay Return are summarized in Table 4-46.

Lake Oroville storage under Alternative 2 is similar to the No Action Alternative with changes of 1 percent or less in all months of all year types.

Lake Oroville elevation under Alternative 2 is similar to the No Action Alternative with changes of 1 percent or less in all months of all year types.

The Feather River Flow below the Thermalito Afterbay Return under Alternative 2 is similar to No Action Alternative with changes of 1 percent or less in all months of all year types except for a 6 percent change in June of critical year types. This change is due to one instance in 1992 of an operations difference that is mirrored by changes in OMR flow and Banks export, as described later in this section.

Table 4-44. Changes in Lake Oroville Storage Under Alternative 2 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (TAF)												
Wet	1,682	1,721	2,177	2,547	2,830	2,942	3,300	3,487	3,441	2,961	2,623	2,109
Above Normal	1,254	1,294	1,461	1,933	2,504	2,894	3,245	3,391	3,227	2,594	2,110	1,653
Below Normal	1,543	1,501	1,513	1,723	2,129	2,404	2,660	2,716	2,531	1,921	1,504	1,295
Dry	1,203	1,153	1,173	1,301	1,578	1,932	2,172	2,203	1,951	1,456	1,277	1,135
Critical	1,081	1,010	1,006	1,095	1,213	1,368	1,397	1,382	1,229	1,025	914	857
Average All Years	1,391	1,381	1,558	1,823	2,142	2,386	2,652	2,747	2,598	2,113	1,813	1,507
Alternative 2 (TAF)												
Wet	1,682	1,720	2,176	2,547	2,830	2,942	3,300	3,487	3,441	2,961	2,623	2,109
Above Normal	1,254	1,294	1,461	1,933	2,503	2,894	3,245	3,390	3,227	2,593	2,109	1,653
Below Normal	1,543	1,501	1,514	1,723	2,130	2,404	2,660	2,717	2,531	1,921	1,504	1,295
Dry	1,202	1,152	1,173	1,301	1,578	1,932	2,172	2,203	1,950	1,456	1,277	1,135
Critical	1,083	1,014	1,012	1,101	1,216	1,374	1,403	1,388	1,229	1,025	914	856
Average All Years	1,391	1,382	1,559	1,824	2,143	2,386	2,653	2,748	2,598	2,113	1,813	1,506
No Action compared to Alternative 2 (TAF)												
Wet	0	0	0	0	0	0	0	0	0	0	0	0
Above Normal	0	0	0	0	0	0	0	0	0	0	0	0
Below Normal	0	0	0	0	0	0	0	0	0	0	0	0
Dry	0	-1	0	0	0	0	0	0	0	0	0	0
Critical	2	5	6	7	3	6	6	6	0	0	0	0
Average All Years	0	0	1	1	0	1	1	1	0	0	0	0
No Action compared to Alternative 2 (%)												
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Below Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Critical	0%	0%	1%	1%	0%	0%	0%	0%	0%	0%	0%	0%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Key:
% = percent
TAF = thousand acre-feet

Table 4-45. Changes in Lake Oroville Elevation Under Alternative 2 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (feet)												
Wet	743	747	796	833	858	867	890	900	898	867	840	792
Above Normal	694	699	719	775	831	863	886	895	885	839	795	745
Below Normal	730	725	727	752	795	821	844	848	832	774	728	703
Dry	688	682	685	703	737	776	799	802	776	721	700	682
Critical	672	663	662	674	691	710	713	711	691	664	648	639
Average All Years	710	708	728	758	791	815	835	841	827	785	755	723
Alternative 2 (feet)												
Wet	743	747	796	833	858	867	890	900	898	867	840	792
Above Normal	694	699	719	775	831	863	886	895	885	839	795	745
Below Normal	730	726	727	752	795	821	844	848	832	774	728	703
Dry	688	682	685	703	737	776	799	802	776	721	700	682
Critical	673	664	663	675	691	711	714	712	691	664	648	639
Average All Years	710	708	728	758	791	815	835	841	827	785	755	723
No Action compared to Alternative 2 (feet)												
Wet	0	0	0	0	0	0	0	0	0	0	0	0
Above Normal	0	0	0	0	0	0	0	0	0	0	0	0
Below Normal	0	0	0	0	0	0	0	0	0	0	0	0
Dry	0	0	0	0	0	0	0	0	0	0	0	0
Critical	0	1	1	1	0	1	1	1	0	0	0	0
Average All Years	0	0	0	0	0	0	0	0	0	0	0	0
No Action compared to Alternative 2 (%)[1]												
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Below Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Critical	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Note:
[1] Percent change estimated based on the change in active storage elevation (i.e., top of dead pool elevation to top of conservation pool elevation) not the change in total absolute elevation.
Key:
% = percent

Table 4-46. Changes in Feather River Flow Downstream from Oroville Dam and Thermalito Afterbay Under Alternative 2 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (cfs)												
Wet	2,124	1,879	3,257	9,436	11,076	12,309	5,889	6,234	3,138	7,085	5,117	8,426
Above Normal	1,516	908	1,807	1,538	2,670	5,724	1,278	1,376	2,233	8,890	7,005	6,992
Below Normal	2,249	1,218	1,538	795	789	1,124	578	1,114	2,246	8,258	5,756	2,558
Dry	1,773	871	1,233	560	705	495	562	1,096	3,063	6,214	1,790	1,361
Critical	815	619	795	308	611	754	605	942	1,774	2,117	1,097	526
Average All Years	1,767	1,206	1,943	3,524	4,303	5,192	2,373	2,749	2,657	6,589	4,102	4,532
Alternative 2 (cfs)												
Wet	2,124	1,878	3,259	9,430	11,076	12,309	5,887	6,233	3,138	7,089	5,118	8,426
Above Normal	1,513	910	1,807	1,539	2,670	5,722	1,278	1,377	2,233	8,892	7,005	6,994
Below Normal	2,249	1,218	1,538	795	789	1,124	578	1,114	2,253	8,260	5,752	2,561
Dry	1,774	871	1,226	560	705	496	562	1,096	3,063	6,217	1,784	1,358
Critical	816	620	795	308	619	754	605	941	1,880	2,121	1,088	525
Average All Years	1,767	1,207	1,941	3,522	4,304	5,192	2,372	2,749	2,673	6,592	4,099	4,532
No Action compared to Alternative 2 (cfs)												
Wet	0	0	2	-6	-1	0	-2	-1	0	4	1	0
Above Normal	-3	2	0	1	0	-2	0	0	1	2	0	2
Below Normal	0	0	0	0	0	0	0	0	7	2	-4	3
Dry	1	0	-7	0	0	1	0	0	0	3	-6	-2
Critical	0	1	0	0	8	0	0	-1	106	4	-9	-1
Average All Years	0	1	-1	-2	1	0	0	0	16	3	-3	0
No Action compared to Alternative 2 (%)												
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Below Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dry	0%	0%	-1%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Critical	0%	0%	0%	0%	1%	0%	0%	0%	6%	0%	-1%	0%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%

Key:
% = percent
cfs = cubic feet per second

Flows into the Yolo Bypass Flows from the Sacramento River into the Yolo Bypass at Fremont Weir are summarized in Table 4-47.

Flows from the Sacramento River into the Yolo Bypass at Fremont Weir under Alternative 2 are similar to the No Action Alternative, with changes less than or equal to 1 percent in all months of all water year types.

Table 4-47. Changes in Flows into the Yolo Bypass at Fremont Weir Under Alternative 2 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (cfs)												
Wet	180	912	8,417	24,250	28,263	18,803	5,735	289	113	0	0	100
Above Normal	100	100	2,726	6,023	12,784	7,789	1,704	100	100	0	0	100
Below Normal	100	100	241	1,005	3,058	880	294	100	100	0	0	100
Dry	100	100	308	903	2,004	1,396	407	100	100	0	0	100
Critical	100	100	147	528	536	396	106	100	100	0	0	100
Average All Years	125	357	3,230	9,076	11,965	7,713	2,243	160	104	0	0	100
Alternative 2 (cfs)												
Wet	180	912	8,433	24,257	28,219	18,799	5,735	289	113	0	0	100
Above Normal	100	100	2,728	6,013	12,730	7,764	1,704	100	100	0	0	100
Below Normal	100	100	241	1,005	3,076	880	294	100	100	0	0	100
Dry	100	100	308	898	2,005	1,395	407	100	100	0	0	100
Critical	100	100	147	527	535	396	106	100	100	0	0	100
Average All Years	125	357	3,235	9,076	11,946	7,708	2,243	160	104	0	0	100
No Action compared to Alternative 2 (cfs)												
Wet	0	0	16	7	-44	-4	0	0	0	0	0	0
Above Normal	0	0	2	-10	-54	-25	0	0	0	0	0	0
Below Normal	0	0	0	0	18	0	0	0	0	0	0	0
Dry	0	0	0	-5	1	-1	0	0	0	0	0	0
Critical	0	0	0	0	-1	0	0	0	0	0	0	0
Average All Years	0	0	6	-1	-20	-5	0	0	0	0	0	0
No Action compared to Alternative 2 (%)												
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Below Normal	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%
Dry	0%	0%	0%	-1%	0%	0%	0%	0%	0%	0%	0%	0%
Critical	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Key:
% = percent
cfs = cubic feet per second

American River Folsom Lake storage and elevation are summarized in Tables 4-48 and 4-49. Changes in flows in the American River downstream from Nimbus Dam are summarized in Table 4-50.

Folsom Lake storage under Alternative 2 is similar to the No Action Alternative, with changes of less than or equal to 1 percent in all months of all water year types.

Folsom Lake elevation under Alternative 2 is similar to the No Action Alternative, with changes of less than or equal to 1 percent in all months of all water year types.

The American River flow below Nimbus Dam is generally similar under Alternative 2 with changes of less than 2 percent in all months of all water year types except for an increase of 5 percent in September of Critical years.

Table 4-48. Changes in Folsom Lake Storage Under Alternative 2 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (TAF)												
Wet	450	433	514	518	515	632	785	950	938	797	706	574
Above Normal	366	375	427	511	530	640	786	945	883	613	542	471
Below Normal	439	426	464	483	533	619	756	840	775	511	455	434
Dry	384	374	401	418	477	576	688	755	648	490	435	408
Critical	317	299	311	318	365	432	472	481	411	325	267	230
Average All Years	400	389	436	459	489	589	712	818	760	585	516	448
Alternative 2 (TAF)												
Wet	450	433	514	518	515	632	785	950	938	797	706	574
Above Normal	367	376	428	511	530	640	786	945	883	613	542	471
Below Normal	439	425	463	482	533	619	756	840	775	512	457	436
Dry	384	374	401	418	477	576	688	755	648	489	433	405
Critical	316	299	311	319	366	433	473	482	411	327	268	230
Average All Years	400	389	436	459	489	589	712	818	760	586	516	448
No Action compared to Alternative 2 (TAF)												
Wet	0	0	0	0	0	0	0	0	0	0	0	0
Above Normal	1	1	1	0	0	0	0	0	0	0	0	1
Below Normal	0	0	0	0	0	0	0	0	0	2	2	1
Dry	1	0	0	-1	0	0	0	0	0	-1	-2	-2
Critical	-1	0	0	1	1	1	1	1	0	2	2	-1
Average All Years	0	0	0	0	0	0	0	0	0	0	0	0
No Action compared to Alternative 2 (%)												
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Below Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-1%	-1%
Critical	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Key:
% = percent
TAF = thousand acre-feet

Table 4-49. Changes in Folsom Lake Elevation Under Alternative 2 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (feet)												
Wet	408	407	419	419	419	433	449	463	462	449	440	425
Above Normal	393	395	405	418	421	434	449	463	457	430	422	413
Below Normal	406	406	411	414	421	431	446	453	446	416	408	406
Dry	398	398	402	405	414	426	438	444	433	414	406	402
Critical	384	382	387	388	395	405	410	411	400	385	373	366
Average All Years	399	399	407	410	415	427	440	449	443	423	415	406
Alternative 2 (feet)												
Wet	408	407	419	419	419	433	449	463	462	449	440	425
Above Normal	393	395	405	418	421	434	449	463	457	430	422	413
Below Normal	406	406	411	414	421	431	446	453	447	416	408	406
Dry	398	398	402	405	414	426	438	444	433	414	406	402
Critical	384	382	387	389	396	405	410	411	400	385	373	365
Average All Years	400	399	407	410	415	427	440	449	443	423	415	406
No Action compared to Alternative 2 (feet)												
Wet	0	0	0	0	0	0	0	0	0	0	0	0
Above Normal	0	0	0	0	0	0	0	0	0	0	0	0
Below Normal	0	0	0	0	0	0	0	0	0	0	0	0
Dry	0	0	0	0	0	0	0	0	0	0	0	0
Critical	0	0	0	0	0	0	0	0	0	0	0	-1
Average All Years	0	0	0	0	0	0	0	0	0	0	0	0
No Action compared to Alternative 2 (%)[1]												
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Below Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Critical	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Note:
[1] Percent change estimated based on the change in active storage elevation (i.e., top of dead pool elevation to top of conservation pool elevation) not the change in total absolute elevation.
Key:
% = percent

Table 4-50. Changes in American River Flows Downstream from Nimbus Dam Under Alternative 2 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (cfs)												
Wet	1,736	3,365	6,769	10,469	10,488	7,194	5,486	5,492	4,111	3,479	2,294	3,238
Above Normal	1,601	2,758	3,643	5,426	7,647	5,971	3,533	2,494	2,348	4,760	1,910	2,082
Below Normal	1,862	2,195	2,227	2,250	4,755	2,165	2,423	1,913	2,131	4,532	1,466	1,200
Dry	1,513	1,733	1,561	1,536	2,119	2,365	2,211	1,937	2,399	2,651	1,433	1,244
Critical	1,238	1,389	1,309	1,065	887	1,010	1,240	1,352	1,779	1,458	1,212	1,027
Average All Years	1,604	2,425	3,595	5,012	5,822	4,243	3,345	3,064	2,807	3,325	1,754	1,971
Alternative 2 (cfs)												
Wet	1,740	3,362	6,765	10,471	10,488	7,194	5,486	5,492	4,111	3,476	2,294	3,245
Above Normal	1,547	2,752	3,640	5,435	7,648	5,977	3,534	2,494	2,348	4,760	1,910	2,071
Below Normal	1,861	2,196	2,226	2,250	4,753	2,165	2,422	1,911	2,125	4,511	1,462	1,204
Dry	1,522	1,743	1,566	1,540	2,113	2,367	2,209	1,935	2,397	2,661	1,459	1,243
Critical	1,229	1,380	1,300	1,057	886	1,010	1,240	1,356	1,796	1,430	1,205	1,070
Average All Years	1,598	2,424	3,593	5,014	5,821	4,244	3,345	3,064	2,808	3,320	1,759	1,979
No Action compared to Alternative 2 (cfs)												
Wet	4	-3	-4	2	0	0	0	0	0	-2	0	7
Above Normal	-54	-6	-3	9	1	6	0	0	1	0	0	-10
Below Normal	0	1	0	0	-2	0	-1	-3	-6	-20	-4	4
Dry	9	10	5	3	-6	2	-2	-2	-2	10	26	-1
Critical	-9	-9	-9	-7	-1	0	0	3	17	-28	-7	42
Average All Years	-6	-1	-2	2	-2	1	0	0	1	-5	5	7
No Action compared to Alternative 2 (%)												
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	-2%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Below Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dry	0%	1%	1%	0%	0%	0%	0%	0%	0%	0%	2%	0%
Critical	0%	-1%	-1%	-1%	0%	0%	0%	0%	1%	-2%	-1%	5%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Key:
% = percent
cfs = cubic feet per second

Stanislaus River New Melones Reservoir storage and elevation are summarized in Tables 4-51 and 4-52. Changes in flows in the Stanislaus River downstream from Goodwin Dam are summarized in Table 4-53.

New Melones storage under Alternative 2 is similar to the No Action Alternative with changes of 1 percent or less in all months of all year types. New Melones elevations under Alternative 2 are similar to under the No Action Alternative with changes of 1 percent or less in all months of all year types. Flows in the Stanislaus River downstream from Goodwin Dam under Alternative 2 are similar to the No Action Alternative with changes of 1 percent or less in all months of all year types.

Table 4-51. Changes in New Melones Reservoir Storage Under Alternative 2 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (TAF)												
Wet	1,379	1,390	1,454	1,562	1,666	1,724	1,758	1,878	1,968	1,890	1,773	1,703
Above Normal	1,030	1,061	1,125	1,215	1,317	1,407	1,414	1,484	1,467	1,373	1,277	1,232
Below Normal	1,294	1,305	1,326	1,351	1,413	1,438	1,390	1,383	1,359	1,268	1,175	1,133
Dry	1,094	1,094	1,106	1,122	1,156	1,188	1,154	1,132	1,088	997	914	871
Critical	624	623	638	645	662	657	602	555	527	477	432	409
Average All Years	1,132	1,142	1,180	1,237	1,305	1,348	1,338	1,373	1,381	1,300	1,209	1,159
Alternative 2 (TAF)												
Wet	1,379	1,390	1,454	1,562	1,666	1,724	1,758	1,878	1,968	1,890	1,773	1,703
Above Normal	1,030	1,061	1,125	1,215	1,317	1,407	1,414	1,484	1,467	1,373	1,277	1,232
Below Normal	1,294	1,305	1,326	1,351	1,413	1,438	1,390	1,383	1,359	1,268	1,175	1,133
Dry	1,095	1,094	1,106	1,122	1,156	1,188	1,154	1,132	1,088	997	914	871
Critical	624	623	638	646	662	657	602	555	527	477	432	409
Average All Years	1,132	1,142	1,180	1,237	1,306	1,348	1,338	1,374	1,381	1,300	1,209	1,159
No Action compared to Alternative 2 (TAF)												
Wet	0	0	0	0	0	0	0	0	0	0	0	0
Above Normal	0	0	0	0	0	0	0	0	0	0	0	0
Below Normal	0	0	0	0	0	0	0	0	0	0	0	0
Dry	0	0	0	0	0	0	0	0	0	0	0	0
Critical	0	0	0	0	0	0	0	0	0	0	0	0
Average All Years	0	0	0	0	0	0	0	0	0	0	0	0
No Action compared to Alternative 2 (%)												
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Below Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Critical	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Key:
% = percent
TAF = thousand acre-feet

Table 4-52. Changes in New Melones Reservoir Elevation Under Alternative 2 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (feet)												
Wet	982	984	992	1,006	1,017	1,024	1,028	1,040	1,048	1,041	1,030	1,023
Above Normal	935	940	948	962	976	988	990	999	997	987	975	970
Below Normal	970	972	974	978	987	991	987	987	985	974	963	957
Dry	946	946	947	950	954	959	957	956	950	938	926	919
Critical	861	861	866	869	874	876	864	853	845	833	823	818
Average All Years	947	948	953	961	970	976	975	978	978	968	957	950
Alternative 2 (feet)												
Wet	982	984	992	1,006	1,017	1,024	1,028	1,040	1,048	1,041	1,030	1,023
Above Normal	935	940	948	962	976	988	990	999	997	987	975	970
Below Normal	970	972	974	978	987	991	987	987	985	974	963	957
Dry	946	946	947	950	954	959	957	956	950	938	926	919
Critical	861	861	867	869	874	876	865	853	845	833	823	818
Average All Years	947	948	953	961	970	976	975	978	978	968	957	950
No Action compared to Alternative 2 (feet)												
Wet	0	0	0	0	0	0	0	0	0	0	0	0
Above Normal	0	0	0	0	0	0	0	0	0	0	0	0
Below Normal	0	0	0	0	0	0	0	0	0	0	0	0
Dry	0	0	0	0	0	0	0	0	0	0	0	0
Critical	0	0	0	0	0	0	0	0	0	0	0	0
Average All Years	0	0	0	0	0	0	0	0	0	0	0	0
No Action compared to Alternative 2 (%)[1]												
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Below Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Critical	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Note:

[1] Percent change estimated based on the change in active storage elevation (i.e., top of dead pool elevation to top of conservation pool elevation) not the change in total absolute elevation.

Key:

% = percent

Table 4-53. Changes in Stanislaus River Flow Downstream from Goodwin Dam Under Alternative 2 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (cfs)												
Wet	789	435	694	1,139	1,273	1,762	1,538	1,642	1,129	617	549	583
Above Normal	706	200	204	229	273	414	1,244	1,085	717	354	286	257
Below Normal	740	209	211	237	316	320	1,262	1,099	448	275	285	254
Dry	698	210	215	236	274	200	872	797	397	279	283	249
Critical	622	200	218	217	265	261	627	607	350	254	236	212
Average All Years	723	278	365	518	595	754	1,158	1,123	680	394	361	351
Alternative 2 (cfs)												
Wet	789	435	694	1,139	1,273	1,762	1,538	1,642	1,129	617	549	583
Above Normal	706	200	204	229	273	414	1,244	1,085	717	354	286	257
Below Normal	740	209	211	237	316	320	1,262	1,099	448	275	285	254
Dry	698	210	215	236	274	200	872	797	397	279	283	249
Critical	622	200	218	217	265	261	627	607	349	253	236	212
Average All Years	723	278	365	518	595	754	1,158	1,123	679	394	361	351
No Action compared to Alternative 2 (cfs)												
Wet	0	0	0	0	0	0	0	0	0	0	0	0
Above Normal	0	0	0	0	0	0	0	0	0	0	0	0
Below Normal	0	0	0	0	0	0	0	0	0	0	0	0
Dry	0	0	0	0	0	0	0	0	0	0	0	0
Critical	0	0	0	0	0	0	0	0	-1	-1	0	0
Average All Years	0	0	0	0	0	0	0	0	-1	0	0	0
No Action compared to Alternative 2 (%)												
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Below Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Critical	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Key:
% = percent
cfs = cubic feet per second

San Luis Reservoir San Luis Reservoir is operated by the CVP and SWP, they each have a share of the total storage. San Luis Reservoir CVP and SWP storage is summarized in Tables 4-54 and 4-55. The elevation in San Luis Reservoir is based on the sum of the CVP and SWP volumes and is summarized in Table 4-56.

San Luis Reservoir CVP storage under Alternative 2 is similar to the No Action Alternative with changes of less than 1 percent in all months of wet, above normal, below normal, and dry years and increases of 1 to 2 percent in most months of critical years.

San Luis Reservoir SWP storage under Alternative 2 is similar to the No Action Alternative with changes of 1 percent or less in all months of all year types.

San Luis elevation under Alternative 2 is similar to the No Action Alternative with changes of less than 1 percent in all months of all year types.

Table 4-54. Changes in San Luis Reservoir CVP Storage Under Alternative 2 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (TAF)												
Wet	234	352	523	652	778	884	810	661	518	309	195	204
Above Normal	232	377	547	648	733	823	724	544	360	163	109	125
Below Normal	239	357	533	641	698	749	662	496	299	221	166	207
Dry	239	345	510	639	711	751	691	562	389	311	209	223
Critical	266	334	460	582	634	629	579	485	332	258	217	229
Average All Years	240	353	516	636	723	786	714	570	405	267	184	200
Alternative 2 (TAF)												
Wet	233	353	523	652	778	884	810	661	518	309	195	204
Above Normal	231	377	547	650	735	824	725	544	360	162	109	124
Below Normal	239	357	532	641	698	749	661	495	298	220	165	206
Dry	238	346	511	640	711	751	692	562	389	311	210	223
Critical	266	336	464	585	639	634	584	491	338	259	218	226
Average All Years	240	353	517	637	724	787	715	571	406	267	184	200
No Action compared to Alternative 2 (TAF)												
Wet	-1	0	0	0	0	0	0	0	0	0	0	0
Above Normal	-1	0	0	1	1	1	1	0	0	-1	0	0
Below Normal	0	0	0	0	0	0	-1	-1	-1	-1	-1	-1
Dry	-1	0	1	1	0	0	0	0	0	0	0	0
Critical	0	2	3	3	5	5	5	5	6	1	2	-3
Average All Years	-1	0	1	1	1	1	1	1	1	0	0	-1
No Action compared to Alternative 2 (%)												
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	-1%	0%	0%	0%	0%	0%	0%	0%	0%	-1%	0%	0%
Below Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	-1%	-1%	-1%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Critical	0%	1%	1%	1%	1%	1%	1%	1%	2%	1%	1%	-1%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Key:
% = percent
TAF = thousand acre-feet

Table 4-55. Changes in San Luis Reservoir SWP Storage Under Alternative 2 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (TAF)												
Wet	310	310	379	555	729	903	788	590	432	431	434	470
Above Normal	236	259	390	550	690	827	713	502	304	302	321	382
Below Normal	258	220	309	433	553	685	608	446	238	264	262	261
Dry	222	232	336	491	616	728	685	563	395	385	184	156
Critical	146	138	203	373	496	556	543	477	354	226	105	81
Average All Years	246	246	335	496	638	768	691	534	365	347	284	295
Alternative 2 (TAF)												
Wet	310	310	377	554	728	903	788	590	432	431	434	470
Above Normal	236	256	387	549	689	826	712	502	304	301	320	381
Below Normal	258	220	309	433	552	685	608	446	238	264	262	261
Dry	222	231	334	490	615	727	684	562	394	384	183	156
Critical	145	137	202	372	493	553	540	474	356	228	104	82
Average All Years	246	245	333	495	636	767	690	533	365	347	283	294
No Action compared to Alternative 2 (TAF)												
Wet	-1	0	-2	-1	0	0	0	0	0	0	0	0
Above Normal	0	-3	-3	-2	-1	-1	-1	-1	-1	-1	-1	-1
Below Normal	0	0	0	0	0	0	0	0	0	0	0	0
Dry	0	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
Critical	-1	-2	-1	-2	-3	-3	-3	-3	3	2	0	0
Average All Years	0	-1	-1	-1	-1	-1	-1	-1	0	0	0	0
No Action compared to Alternative 2 (%)												
Wet	0%	0%	-1%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	0%	-1%	-1%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Below Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Critical	0%	-1%	0%	0%	-1%	-1%	-1%	-1%	1%	1%	0%	0%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Key:
% = percent
TAF = thousand acre-feet

Table 4-56. Changes in San Luis Reservoir Surface Elevation Under Alternative 2 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (feet)												
Wet	399	413	440	471	499	523	507	476	445	422	410	416
Above Normal	390	410	443	469	491	511	493	456	415	390	386	397
Below Normal	393	405	435	459	475	492	477	445	398	391	384	390
Dry	390	405	435	465	483	496	487	464	427	418	379	377
Critical	382	391	414	446	463	468	462	446	416	392	366	365
Average All Years	392	406	435	464	485	503	489	461	425	407	389	393
Alternative 2 (feet)												
Wet	399	413	440	471	499	523	507	476	445	422	410	416
Above Normal	390	410	443	469	491	511	493	456	415	389	386	397
Below Normal	393	405	435	459	475	492	477	445	398	391	384	390
Dry	390	405	435	465	483	496	487	464	427	418	379	377
Critical	382	391	414	446	463	468	463	447	417	392	367	365
Average All Years	392	406	435	464	485	503	489	461	426	407	389	393
No Action compared to Alternative 2 (feet)												
Wet	0	0	0	0	0	0	0	0	0	0	0	0
Above Normal	0	0	0	0	0	0	0	0	0	0	0	0
Below Normal	0	0	0	0	0	0	0	0	0	0	0	0
Dry	0	0	0	0	0	0	0	0	0	0	0	0
Critical	0	0	0	0	0	0	0	0	1	1	0	0
Average All Years	0	0	0	0	0	0	0	0	0	0	0	0
No Action compared to Alternative 2 (%)												
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Below Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Critical	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Key:
% = percent

Changes in Delta Conditions

San Joaquin River Delta Inflow The San Joaquin River flow at Vernalis was selected to represent the San Joaquin River inflow to the Sacramento-San Joaquin Delta and is summarized in Table 4-57.

The San Joaquin River flow at Vernalis, the San Joaquin River inflow to the Sacramento-San Joaquin Delta, under Alternative 2 is similar to the No Action Alternative with changes of less than 1 percent in all months of all year types.

Table 4-57. Changes in San Joaquin River Flows at Vernalis Under Alternative 2 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (cfs)												
Wet	3,041	3,335	5,580	10,083	12,545	14,021	13,228	11,380	8,751	5,260	2,788	3,061
Above Normal	2,386	2,213	3,279	4,375	6,150	6,704	7,694	5,514	3,482	2,016	1,765	2,214
Below Normal	2,869	2,552	2,414	2,701	4,590	4,249	5,597	3,698	2,029	1,491	1,576	1,997
Dry	2,554	2,344	2,084	2,295	3,120	3,599	4,311	3,240	1,729	1,221	1,343	1,762
Critical	2,196	1,975	1,842	1,757	2,223	2,198	2,129	1,848	1,184	933	983	1,395
Average All Years	2,672	2,611	3,391	5,070	6,655	7,278	7,528	6,039	4,194	2,622	1,847	2,223
Alternative 2 (cfs)												
Wet	3,041	3,335	5,580	10,083	12,545	14,021	13,228	11,380	8,751	5,260	2,788	3,061
Above Normal	2,386	2,213	3,279	4,375	6,150	6,704	7,695	5,514	3,482	2,016	1,765	2,214
Below Normal	2,869	2,552	2,414	2,701	4,590	4,249	5,597	3,698	2,029	1,491	1,576	1,997
Dry	2,554	2,344	2,084	2,295	3,119	3,599	4,311	3,240	1,729	1,221	1,343	1,762
Critical	2,196	1,975	1,842	1,757	2,223	2,198	2,129	1,848	1,183	932	983	1,395
Average All Years	2,672	2,611	3,391	5,070	6,655	7,278	7,528	6,039	4,194	2,622	1,847	2,223
No Action compared to Alternative 2 (cfs)												
Wet	0	0	0	0	0	0	0	0	0	0	0	0
Above Normal	0	0	0	0	0	0	1	0	0	0	0	0
Below Normal	0	0	0	0	0	0	0	0	0	0	0	0
Dry	0	0	0	0	-1	0	0	0	0	0	0	0
Critical	0	0	0	0	0	0	0	0	-1	-1	0	0
Average All Years	0	0	0	0	0	0	0	0	0	0	0	0
No Action compared to Alternative 2 (%)												
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Below Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Critical	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Key:
% = percent
cfs = cubic feet per second

Sacramento River Delta Inflow The Sacramento River flow at Freeport was selected to represent the Sacramento River inflow to the Sacramento-San Joaquin Delta and is summarized in Table 4-58.

The Sacramento River flow at Freeport under Alternative 2 is similar to the No Action Alternative with changes of 1 percent or less in all months of all year types.

Table 4-58. Changes in Sacramento River Flow at Freeport Under Alternative 2 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (cfs)												
Wet	13,044	20,443	36,311	49,134	56,402	48,167	35,405	29,889	20,143	20,340	16,057	27,926
Above Normal	10,198	17,154	24,532	38,476	46,555	40,701	24,151	16,803	13,676	23,093	16,887	21,166
Below Normal	12,209	15,828	15,772	18,275	30,217	18,597	14,072	12,614	12,955	22,230	15,653	12,113
Dry	10,200	12,772	13,617	17,174	23,405	21,310	14,907	11,791	12,985	17,454	10,500	9,981
Critical	8,103	8,465	11,077	14,101	15,881	12,532	10,341	8,367	9,833	10,892	8,758	7,214
Average All Years	11,064	15,679	22,460	30,383	37,350	31,251	22,092	17,933	14,899	18,943	13,711	17,325
Alternative 2 (cfs)												
Wet	13,033	20,482	36,300	49,134	56,397	48,153	35,405	29,881	20,147	20,344	16,057	27,923
Above Normal	10,190	17,195	24,498	38,487	46,563	40,738	24,151	16,802	13,679	23,094	16,914	21,169
Below Normal	12,212	15,824	15,769	18,274	30,205	18,597	14,071	12,617	12,954	22,231	15,658	12,113
Dry	10,217	12,795	13,618	17,174	23,402	21,311	14,906	11,791	12,985	17,478	10,499	9,981
Critical	8,088	8,486	11,081	14,094	15,847	12,532	10,341	8,367	9,944	10,808	8,748	7,161
Average All Years	11,062	15,705	22,452	30,383	37,343	31,253	22,091	17,931	14,917	18,939	13,714	17,317
No Action compared to Alternative 2 (cfs)												
Wet	-11	39	-11	0	-5	-14	0	-8	4	4	0	-3
Above Normal	-8	41	-34	11	8	37	0	-1	3	1	27	3
Below Normal	3	-4	-3	-1	-12	0	-1	3	-1	1	5	0
Dry	17	23	1	0	-3	1	-1	0	0	24	-1	0
Critical	-15	21	4	-7	-34	0	0	0	111	-84	-10	-53
Average All Years	-2	26	-8	0	-7	2	-1	-2	18	-4	3	-8
No Action compared to Alternative 2 (%)												
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Below Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Critical	0%	0%	0%	0%	0%	0%	0%	0%	1%	-1%	0%	-1%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Key:
% = percent
cfs = cubic feet per second

Sacramento-San Joaquin Delta Outflow The Sacramento-San Joaquin Delta outflow is summarized in Table 4-59.

The Sacramento-San Joaquin Delta outflow under Alternative 2 is similar to the No Action Alternative with changes of 1 percent or less in all months of all year types.

Table 4-59. Changes in Delta Outflow Under Alternative 2 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (cfs)												
Wet	8,445	17,135	47,370	89,535	101,936	81,603	55,719	38,900	18,814	10,606	4,430	19,051
Above Normal	5,404	12,250	24,302	49,849	67,107	52,281	32,579	19,505	8,147	10,852	4,082	11,130
Below Normal	7,669	10,903	9,449	17,479	36,356	17,934	17,060	12,805	7,484	8,246	4,129	3,550
Dry	5,539	7,902	7,600	15,914	25,698	22,720	16,749	11,073	7,229	5,144	4,178	3,194
Critical	4,126	4,980	6,727	11,691	15,322	12,160	9,391	6,693	5,845	4,053	3,786	3,000
Average All Years	6,518	11,494	22,978	44,229	56,347	43,889	30,580	20,824	10,880	8,037	4,179	9,499
Alternative 2 (cfs)												
Wet	8,445	17,158	47,378	89,542	101,885	81,586	55,719	38,893	18,818	10,607	4,430	19,051
Above Normal	5,404	12,312	24,272	49,835	67,056	52,295	32,579	19,504	8,150	10,851	4,082	11,130
Below Normal	7,669	10,903	9,448	17,479	36,364	17,933	17,059	12,809	7,483	8,246	4,129	3,549
Dry	5,539	7,906	7,598	15,909	25,696	22,719	16,748	11,073	7,229	5,144	4,175	3,195
Critical	4,124	4,980	6,726	11,693	15,286	12,153	9,391	6,693	5,845	4,053	3,780	3,000
Average All Years	6,518	11,512	22,975	44,228	56,318	43,885	30,580	20,822	10,881	8,038	4,177	9,499
No Action compared to Alternative 2 (cfs)												
Wet	0	23	8	7	-51	-17	0	-7	4	1	0	0
Above Normal	0	62	-30	-14	-51	14	0	-1	3	-1	0	0
Below Normal	0	0	-1	0	8	-1	-1	4	-1	0	0	-1
Dry	0	4	-2	-5	-2	-1	-1	0	0	0	-3	1
Critical	-2	0	-1	2	-36	-7	0	0	0	0	-6	0
Average All Years	0	18	-3	-1	-29	-4	0	-2	1	1	-2	0
No Action compared to Alternative 2 (%)												
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Below Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Critical	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Key:
% = percent
cfs = cubic feet per second

Old and Middle River Flow The OMR condition in the Sacramento-San Joaquin Delta outflow is summarized in Table 4-60.

OMR under Alternative 2 is similar to the No Action Alternative in all months and year types with change of less than 1 percent except in June and July of Critical years where there is an increase of 6 percent and a reduction of 2 percent respectively. The average is from a single critical year, 1992 with a change in OMR from -1943 cfs in the No Action to -3164 cfs in Alterative 2. The change in OMR was mainly driven by a single month increase in Banks pumping, which in turn was driven by a slight decrease in SWP San Luis storage. This is a unique occurrence without large consequences that may not have occurred under shorter term real time operation decisions and is not expected to occur on a regular basis. CalSim II modifies exports as required in order to maintain the final OMR within regulatory limits.

Table 4-60. Changes in OMR Conditions Under Alternative 2 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (cfs)												
Wet	-5,951	-7,307	-5,524	-1,904	-2,002	-1,613	3,109	2,002	-4,331	-8,978	-10,576	-9,279
Above Normal	-5,597	-6,892	-6,821	-3,501	-3,371	-4,176	1,189	408	-4,525	-9,238	-10,834	-9,539
Below Normal	-5,714	-6,856	-7,653	-4,379	-3,499	-4,036	157	-327	-3,445	-10,570	-9,719	-8,150
Dry	-5,507	-6,045	-6,697	-4,620	-3,705	-3,079	-675	-925	-3,405	-9,211	-4,766	-6,299
Critical	-4,670	-4,396	-4,948	-4,339	-2,969	-1,782	-797	-982	-1,608	-4,015	-3,372	-3,794
Average All Years	-5,567	-6,447	-6,217	-3,508	-2,977	-2,727	914	286	-3,619	-8,564	-8,031	-7,639
Alternative 2 (cfs)												
Wet	-5,941	-7,319	-5,524	-1,904	-2,004	-1,612	3,109	2,002	-4,331	-8,981	-10,576	-9,276
Above Normal	-5,591	-6,874	-6,823	-3,515	-3,370	-4,177	1,189	408	-4,524	-9,239	-10,858	-9,542
Below Normal	-5,717	-6,852	-7,651	-4,379	-3,496	-4,037	157	-327	-3,445	-10,569	-9,723	-8,152
Dry	-5,521	-6,062	-6,700	-4,620	-3,705	-3,079	-675	-925	-3,405	-9,232	-4,768	-6,299
Critical	-4,665	-4,413	-4,953	-4,331	-2,970	-1,789	-797	-982	-1,710	-3,938	-3,369	-3,746
Average All Years	-5,566	-6,454	-6,219	-3,509	-2,977	-2,728	914	286	-3,634	-8,558	-8,035	-7,632
No Action compared to Alternative 2 (cfs)												
Wet	10	-12	0	0	-2	1	0	0	0	-3	0	3
Above Normal	6	18	-2	-14	1	-1	0	0	1	-1	-24	-3
Below Normal	-3	4	2	0	3	-1	0	0	0	1	-4	-2
Dry	-14	-17	-3	0	0	0	0	0	0	-21	-2	0
Critical	5	-17	-5	8	-1	-7	0	0	-102	77	3	48
Average All Years	1	-7	-2	-1	0	-1	0	0	-15	6	-4	7
No Action compared to Alternative 2 (%)												
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Below Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Critical	0%	0%	0%	0%	0%	0%	0%	0%	6%	-2%	0%	-1%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Key:
% = percent
cfs = cubic feet per second
OMR = Old and Middle River

Changes in CVP and SWP Exports The CVP and SWP both deliver water to a variety of customers under different contractual terms. The comparison of changes for CVP and SWP water supply delivery is divided into four categories, including CVP NOD, CVP SOD, CVP Eastside and SWP.

Jones Pumping Plant (CVP Exports) Jones Pumping Plant is the major CVP delta export facility. Exports at Jones Pumping Plant under Alternative 2 as compared to the No Action Alternative are summarized in Table 4-61.

Exports at Jones Pumping Plant under Alternative 2 are similar to the No Action with increases of up to 2 percent, except in July of critical years where it is reduced by 4 percent.

Table 4-61. Changes in Exports at Jones Pumping Plant Under Alternative 2 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (cfs)												
Wet	3,388	3,612	4,042	3,571	3,986	3,748	1,606	1,549	3,751	4,048	4,578	4,083
Above Normal	3,221	3,857	3,754	2,695	2,873	3,512	1,104	898	2,794	3,202	4,478	3,875
Below Normal	3,595	3,603	4,104	3,192	2,841	2,831	1,009	819	1,932	4,239	3,811	3,979
Dry	3,263	3,263	3,735	3,227	2,797	2,329	1,211	992	1,549	3,373	2,569	3,334
Critical	2,792	2,396	2,816	2,668	1,912	1,337	863	827	608	2,068	2,415	2,664
Average All Years	3,272	3,387	3,750	3,165	3,063	2,889	1,241	1,106	2,358	3,485	3,653	3,646
Alternative 2 (cfs)												
Wet	3,378	3,626	4,044	3,571	3,987	3,746	1,607	1,549	3,751	4,046	4,578	4,080
Above Normal	3,214	3,881	3,756	2,707	2,873	3,513	1,104	898	2,795	3,201	4,504	3,877
Below Normal	3,598	3,598	4,101	3,192	2,837	2,832	1,009	819	1,926	4,238	3,812	3,974
Dry	3,277	3,283	3,743	3,227	2,797	2,327	1,211	992	1,550	3,385	2,577	3,336
Critical	2,806	2,433	2,836	2,669	1,941	1,340	863	827	607	1,986	2,411	2,588
Average All Years	3,273	3,404	3,756	3,167	3,067	2,888	1,241	1,106	2,358	3,475	3,658	3,634
No Action compared to Alternative 2 (cfs)												
Wet	-11	13	2	0	1	-2	0	0	0	-2	0	-3
Above Normal	-7	24	3	12	1	1	0	0	1	-1	26	3
Below Normal	3	-5	-2	0	-3	1	0	0	-6	0	1	-4
Dry	14	20	8	0	0	-2	0	0	0	12	8	2
Critical	13	37	20	1	28	4	0	0	-1	-82	-4	-76
Average All Years	1	18	6	2	4	0	0	0	-1	-10	6	-12
No Action compared to Alternative 2 (%)												
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%
Below Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dry	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Critical	0%	2%	1%	0%	1%	0%	0%	0%	0%	-4%	0%	-3%
Average All Years	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Key:
% = percent
cfs = cubic feet per second

Banks Pumping Plant (SWP Exports) Banks Pumping plant is the major SWP Delta export facility. Exports at Banks Pumping Plant under Alternative 2 as compared to the No Action Alternative are summarized in Table 4-62.

Banks export under Alternative 2 is similar to the No Action Alternative with change of less than 2 percent in all months and year types except in June of Critical years where it increases by 20 percent. The average is from a single critical year, 1992 with a change in Banks exports from 448 cfs in the No Action to 1769 cfs in Alternative 2. The change in Banks exports was mainly driven by a slight decrease in SWP San Luis storage that had accumulated over several months. This is unique occurrence without large consequences that may not have occurred under shorter term real time operation decisions and is not expected to occur on a regular basis.

Table 4-62. Changes in Exports at Banks Pumping Plant Under Alternative 2 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (cfs)												
Wet	3,287	4,743	5,101	4,768	5,634	5,972	1,817	1,822	3,790	6,719	7,102	6,538
Above Normal	2,932	3,767	5,324	3,670	4,444	4,562	1,089	814	2,503	6,364	7,004	6,680
Below Normal	2,788	4,068	5,476	3,099	3,477	3,700	1,238	814	1,577	6,472	6,415	5,105
Dry	2,812	3,464	4,550	3,144	2,975	2,846	1,366	1,040	1,766	5,755	2,263	3,649
Critical	2,290	2,434	3,359	3,032	2,555	1,581	698	628	548	1,295	675	1,397
Average All Years	2,902	3,848	4,797	3,720	4,057	4,038	1,350	1,161	2,321	5,601	4,873	4,912
Alternative 2 (cfs)												
Wet	3,287	4,743	5,100	4,768	5,635	5,974	1,817	1,822	3,790	6,724	7,102	6,538
Above Normal	2,932	3,723	5,324	3,674	4,443	4,562	1,089	814	2,502	6,365	7,004	6,680
Below Normal	2,788	4,068	5,476	3,099	3,476	3,700	1,238	814	1,583	6,472	6,418	5,111
Dry	2,814	3,462	4,544	3,144	2,975	2,848	1,366	1,040	1,766	5,765	2,256	3,648
Critical	2,273	2,415	3,344	3,022	2,527	1,585	698	628	659	1,292	675	1,421
Average All Years	2,900	3,838	4,793	3,719	4,053	4,040	1,350	1,161	2,338	5,604	4,872	4,916
No Action compared to Alternative 2 (cfs)												
Wet	0	0	-1	0	1	2	0	0	0	5	0	0
Above Normal	0	-43	0	4	-1	0	0	0	-1	2	0	0
Below Normal	0	0	0	0	-1	0	0	0	6	0	3	6
Dry	2	-2	-6	0	0	2	0	0	0	10	-6	-1
Critical	-18	-19	-14	-10	-28	4	0	0	111	-2	0	24
Average All Years	-2	-10	-4	-1	-4	2	0	0	17	4	-1	4
No Action compared to Alternative 2 (%)												
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	0%	-1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Below Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Critical	-1%	-1%	0%	0%	-1%	0%	0%	0%	20%	0%	0%	2%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%

Key:
% = percent
cfs = cubic feet per second

Changes in CVP and SWP Water Supply Delivery

CVP Delivery North of the Delta CVP NOD water deliveries are summarized in Table 4-63.

CVP NOD delivery under Alternative 2 is similar to the No Action Alternative with less than a 3 percent change (critical years from 23 TAF to 22 TAF) in all year types for contractors.

Table 4-63. Changes in CVP North-of-Delta Water Deliveries Under Alternative 2 as Compared to the No Action Alternative, by Sacramento Water Year Type

Alternative/Comparison	Wet	Above Normal	Below Normal	Dry	Critical	Average All Years
CVP Agricultural Water Service Contractors						
No Action (TAF)	305	263	167	89	23	186
Alternative 2 (TAF)	304	264	168	89	22	186
No Action Compared to Alternative 2 (TAF)	0	1	1	0	-1	0
No Action Compared to Alternative 2 (%)	0%	0%	0%	0%	-3%	0%
CVP M&I (including Contra Costa)						
No Action (TAF)	386	383	333	292	245	335
Alternative 2 (TAF)	386	383	333	292	244	335
No Action Compared to Alternative 2 (TAF)	0	0	0	0	-1	0
No Action Compared to Alternative 2 (%)	0%	0%	0%	0%	0%	0%
CVP Sacramento River Settlement Contractors						
No Action (TAF)	1,844	1,865	1,890	1,915	1,748	1,857
Alternative 2 (TAF)	1,844	1,865	1,890	1,915	1,747	1,857
No Action Compared to Alternative 2 (TAF)	1	0	0	0	-1	0
No Action Compared to Alternative 2 (%)	0%	0%	0%	0%	0%	0%
CVP Refuge Level 2 Deliveries						
No Action (TAF)	88	85	86	85	63	83
Alternative 2 (TAF)	88	85	86	85	62	83
No Action Compared to Alternative 2 (TAF)	0	0	0	0	-1	0
No Action Compared to Alternative 2 (%)	0%	0%	0%	0%	-1%	0%
Total CVP NOD Deliveries						
No Action (TAF)	2,622	2,596	2,477	2,381	2,079	2,460
Alternative 2 (TAF)	2,622	2,597	2,478	2,382	2,075	2,460
No Action Compared to Alternative 2 (TAF)	0	1	1	0	-4	0
No Action Compared to Alternative 2 (%)	0%	0%	0%	0%	0%	0%

Key:
% = percent
CVP = Central Valley Project
NOD = North-of-Delta
TAF = thousand acre-feet

CVP Delivery South of the Delta CVP SOD water deliveries are summarized in Table 4-64.

CVP SOD water deliveries under Alternative 2 are similar to the No Action Alternative with reductions of 1 percent or less in all year types for all contractors.

Table 4-64. Changes in CVP South-of-Delta Water Deliveries Under Alternative 2 as Compared to the No Action Alternative, by Sacramento Water Year Type

Alternative/Comparison	Wet	Above Normal	Below Normal	Dry	Critical	Average All Years
CVP Agricultural Water Service Contractors						
No Action (TAF)	1,316	885	752	480	137	795
Alternative 2 (TAF)	1,316	888	753	482	135	796
No Action Compared to Alternative 2 (TAF)	0	3	1	2	-2	1
No Action Compared to Alternative 2 (%)	0%	0%	0%	0%	-1%	0%
CVP M&I						
No Action (TAF)	132	112	114	104	85	113
Alternative 2 (TAF)	132	112	114	104	84	113
No Action Compared to Alternative 2 (TAF)	0	0	0	0	0	0
No Action Compared to Alternative 2 (%)	0%	0%	0%	0%	0%	0%
San Joaquin River Exchange Contractors						
No Action (TAF)	874	870	858	871	752	853
Alternative 2 (TAF)	874	870	858	871	752	853
No Action Compared to Alternative 2 (TAF)	0	0	0	0	0	0
No Action Compared to Alternative 2 (%)	0%	0%	0%	0%	0%	0%
CVP Refuge Level 2 Deliveries						
No Action (TAF)	280	276	277	276	249	273
Alternative 2 (TAF)	280	276	277	276	249	273
No Action Compared to Alternative 2 (TAF)	0	0	0	0	0	0
No Action Compared to Alternative 2 (%)	0%	0%	0%	0%	0%	0%
Total CVP SOD Deliveries						
No Action (TAF)	2,601	2,143	2,001	1,729	1,223	2,034
Alternative 2 (TAF)	2,601	2,146	2,003	1,732	1,221	2,035
No Action Compared to Alternative 2 (TAF)	0	3	1	2	-2	1
No Action Compared to Alternative 2 (%)	0%	0%	0%	0%	0%	0%

Key:
% = percent
CVP = Central Valley Project
M&I = municipal and industrial
SOD = South-of-Delta
TAF = thousand acre-feet

CVP Eastside Delivery CVP SOD water deliveries are summarized in Table 4-65.

CVP Eastside water deliveries under Alternative 2 are similar to the No Action Alternative with changes to all contractors in all year types less than 1 percent.

Table 4-65. Changes in CVP Eastside Water Deliveries Under Alternative 2 as Compared to the No Action Alternative, by Sacramento Water Year Type

Alternative/Comparison	Wet	Above Normal	Below Normal	Dry	Critical	Average All Years
Water Rights						
No Action (TAF)	505	518	532	532	443	508
Alternative 2 (TAF)	505	518	532	532	443	508
No Action Compared to Alternative 2 (TAF)	0	0	0	0	0	0
No Action Compared to Alternative 2 (%)	0%	0%	0%	0%	0%	0%
CVP Water Service Contracts						
No Action (TAF)	146	116	117	86	12	103
Alternative 2 (TAF)	146	116	117	86	12	103
No Action Compared to Alternative 2 (TAF)	0	0	0	0	0	0
No Action Compared to Alternative 2 (%)	0%	0%	0%	0%	0%	0%
Total Eastside Deliveries						
No Action (TAF)	651	634	649	618	454	611
Alternative 2 (TAF)	651	634	649	618	455	612
No Action Compared to Alternative 2 (TAF)	0	0	0	0	0	0
No Action Compared to Alternative 2 (%)	0%	0%	0%	0%	0%	0%

Key:
% = percent
CVP = Central Valley Project
TAF = thousand acre-feet

CVP Total Water Delivery CVP Total water deliveries are summarized in Table 4-66.

CVP total water deliveries under Alternative 2 are similar to the No Action Alternative with changes to all contractors in all year types less than 1 percent.

Table 4-66. Changes in CVP Total Water Deliveries Under Alternative 2 as Compared to the No Action Alternative, by Sacramento Water Year Type

Alternative/Comparison	Wet	Above Normal	Below Normal	Dry	Critical	Average All Years
All CVP Deliveries						
No Action (TAF)	5,875	5,373	5,128	4,729	3,756	5,105
Alternative 2 (TAF)	5,875	5,377	5,130	4,732	3,751	5,106
No Action Compared to Alternative 2 (TAF)	0	4	2	3	-6	1
No Action Compared to Alternative 2 (%)	0%	0%	0%	0%	0%	0%

Key:
% = percent
CVP = Central Valley Project
TAF = thousand acre-feet

SWP Table A and Article 21 Delivery SWP CVP SOD water deliveries are summarized in Table 4-67.

SWP total water deliveries under Alternative 2 are similar to the No Action Alternative with changes to all contractors in all year types less than 1 percent except for a reduction in Article 21 delivery of 3 percent in wet years.

Table 4-67. Changes in SWP Table A and Article 21 Water Deliveries Under Alternative 2 as Compared to the No Action Alternative, by Sacramento Water Year Type

Table A (TAF)						
Alternative/Comparison	**Wet**	**Above Normal**	**Below Normal**	**Dry**	**Critical**	**Average All Years**
No Action (TAF)	3,178	2,684	2,526	2,052	1,207	2,449
Alternative 2 (TAF)	3,181	2,682	2,526	2,051	1,209	2,450
No Action Compared to Alternative 2 (TAF)	3	-2	0	0	3	1
No Action Compared to Alternative 2 (%)	0%	0%	0%	0%	0%	0%
Article 21 (TAF)						
Alternative/Comparison	**Wet**	**Above Normal**	**Below Normal**	**Dry**	**Critical**	**Average All Years**
No Action (TAF)	76	81	36	13	10	46
Alternative 2 (TAF)	74	81	36	13	10	46
No Action Compared to Alternative 2 (TAF)	-2	0	0	0	0	0
No Action Compared to Alternative 2 (%)	-3%	0%	0%	0%	0%	0%

Key:
% = percent
CVP = Central Valley Project
SWP = State Water Project
TAF = thousand acre-feet

Summary of Environmental Consequences

Table 4-68 presents the results of the environmental consequences analysis for implementing the action alternatives compared to the No Action Alternative.

Table 4-68. Comparison of Action Alternatives to No Action Alternative

Alternative	Potential Change	Consideration for Mitigation Measures
Alternative 1	*Trinity River* Trinity Lake storage would be similar to the No Action Alternative, with less than a 1% decrease in most months and year types—with the exceptions of a 2% decrease in October, November, and December of extremely wet years and in September of dry years, and a 4% decrease in September of critically dry years. Trinity Lake elevation would be similar to the No Action Alternative with changes less than, or equal to, 1% in all months and year types. Lewiston Dam flow releases to the Trinity River would increase in August and September in all year types, from 2% in August of extremely wet years to 115% in September of critically dry years, and decrease by 10% in November of extremely wet years, 10% in October of critically dry years, and 7% in February of normal years. TRD diversions to the Sacramento Basin at Lewiston Reservoir would change in various months—with reductions of 16% in July during critically dry years to increases of 13% in March of critically dry years. The long-term changes range from -7% in October to 3% in February. *Klamath River* Flows in Klamath River, at Klamath, would increase in August and September in all year types (except extremely wet), ranging from 1% in August of wet years to 69% in September of critically dry years. In all other months and year types, changes were 1% or less. *Clear Creek* Storage and elevation levels in Whiskeytown Lake would be similar to the No Action Alternative with changes less than, or equal to, 1% in all months and year types. Flows in Clear Creek, downstream from Whiskeytown Dam, would be similar to the No Action Alternative with changes less than, or equal to, 1% in all months of all year types. *Sacramento River* Shasta Lake storage and elevation levels would be similar to the No Action Alternative with changes less than, or equal to, 1% in all months and year types. Sacramento River flow, downstream from Keswick Dam, would be similar to the No Action Alternative with most months of all year types changing less than 1%, with the exception of reductions of 2% in August of dry years and 4% in September of critical years.	Environmental effects associated with changes in water storage, flows and supply may affect physical conditions in other resource categories and are related to impacts on surface water quality (as described in Chapter 5, “Surface Water Quality”), groundwater (as described in Chapter 6, “Groundwater Resources/ Groundwater Quality”), biological resources (as described in Chapter 7, “Biological Resources – Fisheries” and Chapter 8, “Biological Resources – Terrestrial”), hydropower (as described in Chapter 9, “Hydropower Generation”), agriculture (as described in Chapter 11, “Agricultural Resources”), and recreation (as described in Chapter 12, “Socioeconomics”) Mitigation measures, if needed, related to environmental changes caused by changes in surface water conditions are presented in Chapters 5, 6, 7, 8, 9, 11, and 12.

Table 4-68. Comparison of Action Alternatives to No Action Alternative (contd.)

Alternative	Potential Change	Consideration for Mitigation Measures
Alternative 1 (contd.)	*Feather River* Lake Oroville storage and elevation, and Feather River flow below Oroville Dam and Thermalito Afterbay Return, would be similar to the No Action Alternative with changes of 1% or less in all months of all year types except for an increase of 6% in June of Critical years. This was driven by a release from Lake Oroville to support an increase in Banks pumping, which in turn was driven by a slight decrease in SWP San Luis storage. This is a unique occurrence without large consequences that may not have occurred under shorter term real time operation decisions and is not expected to occur on a regular basis. *Sacramento River Flow Into the Yolo Bypass at Fremont Weir* Flows from the Sacramento River into the Yolo Bypass would be similar to the No Action Alternative, with changes less than, or equal to, 1% in all months of all water year types. *American River* Folsom Lake storage and elevation would be similar to the No Action Alternative, with changes of less than, or equal to, 1% in all months of all water year types, except for a 2% increase in storage in August of critical years. The American River flow, below Nimbus Dam, would be generally similar to the No Action Alternative with changes of less than 3% in all months of all water year types, except for a reduction of 5% in July and an increase of 5% in September of critical years. *Stanislaus River* New Melones storage and elevation, and flows in the Stanislaus River downstream from Goodwin Dam, would be similar to the No Action Alternative with changes of 1% or less in all months of all year types. *San Luis Reservoir Storage* San Luis Reservoir CVP storage would be similar to the No Action Alternative with increases of 0 to 2% in most months of most years, but up to an increase of 4% in June of critical years. San Luis Reservoir SWP storage would be similar to the No Action Alternative with changes of less than 1% in all months of all year types. San Luis elevation would be similar to the No Action Alternative with changes of less than 1% in all months of all year types. *San Joaquin River Delta Inflow* The San Joaquin River inflow to the Sacramento-San Joaquin Delta would be similar to the No Action Alternative with changes of less than 1% in all months of all year types. *Sacramento River Delta Inflow* The Sacramento River flow at Freeport would be similar to the No Action Alternative with changes of less than 1% in all months of all year types.	See above

Table 4-68. Comparison of Action Alternatives to No Action Alternative (contd.)

Alternative	Potential Change	Consideration for Mitigation Measures
Alternative 1 (contd.)	*Sacramento-San Joaquin Delta Outflow* The Sacramento-San Joaquin Delta outflow would be similar to the No Action Alternative with changes of less than 1% in all months of all year types. *Old and Middle River Flow (OMR)* OMR conditions would be similar to the No Action Alternative in all months and year types with reductions of 0 to 3%, except in June of critical years where there is an increase of 6%. This change in June of critical years is from a single critical year, 1992, with a change in OMR from -1943 cfs in the No Action to -3140 cfs in Alternative 1. This change in OMR was mainly driven by a single-month increase in Banks pumping, which in turn was driven by a slight decrease in SWP San Luis storage. CalSim II modifies exports as required, in order to maintain the final OMR within regulatory limits, which was -3500 cfs in this month (June). *Jones Pumping Plant (CVP Exports)* Exports at Jones Pumping Plant would be similar to the No Action Alternative with decreases of 0 to 3%, except in July, and August of critical years, where it is reduced by 7%. *Banks Pumping Plant (SWP Exports)* Banks export would be similar to the No Action Alternative in all months and year types with reduction of 0 to 3%, except in June of critical years where it increases by 21%. The June increase is from a single critical year, 1992, with a change in Banks' exports from 448 cfs in the No Action to 1,743 cfs in Alternative 1. This is a unique occurrence—that may not have occurred under shorter-term real-time operation decisions—and is not expected to occur on a regular basis. *CVP North of Delta Water Deliveries* CVP North of Delta delivery would be similar to under the No Action Alternative with less than a 5% change in all year types for all water contractors/customers, except critical years for CVP Agricultural Water Service Contractors, where it is reduced by 10% percent (23 TAF to 21 TAF). *CVP South of Delta water deliveries* CVP South of Delta delivery would be similar to under the No Action Alternative with less than a 3% change in all year types for all water contractors/customers, except critical years for CVP Agricultural Water Service Contractors, where it is reduced by 7% percent (137 TAF to 127 TAF). *CVP Eastside Water Deliveries* CVP Eastside water deliveries would be similar to the No Action Alternative with changes to all contractors in all year types of less than 1%. *Total CVP Deliveries* Long-term average CVP water deliveries would be similar to the No Action Alternative with changes in all year types of less than 1%, with an average reduction of 13 TAF. This represents reductions of 22 TAF in critical years, 24 TAF in dry years, 13 TAF in below normal years, 4 TAF in above normal years, and 4 TAF in wet years.	See above

Table 4-68. Comparison of Action Alternatives to No Action Alternative (contd.)

Alternative	Potential Change	Consideration for Mitigation Measures
Alternative 2	*Trinity River* Trinity Lake storage would be similar to the No Action Alternative, with 1% or less change in most months and year types—with the exceptions of 2% decreases in October of extremely wet years and in September of critically dry years, and increases of 2% in dry years and 2% to 4% in June, July and August of critically dry years. Trinity Lake elevation would be similar to the No Action Alternative with increases of 1% or less in all months of all year types. Lewiston Dam flow releases to the Trinity River would increase in August and September in all year types, from 2% in August of extremely wet years to 132% in September of critically dry years. Lewiston Dam releases to the Trinity River show reductions from 1% to 38% in May and June of most year types, with the larger reductions in the drier years, as well as decreases of 8% in November of extremely wet years and 6% in February of normal years. TRD diversions to the Sacramento Basin at Lewiston Reservoir would change in various months—with reductions of up to 11% in February of critically dry years to increases of up to 9% in February of normal years. The long-term changes range from -4% in December to 4% in both May and June. *Klamath River* Flows in Klamath River, at Klamath, would increase in August and September in all year types (except extremely wet), ranging from 1% in August and September of wet years to 69% in September of critically dry years. Flows would be reduced in May and June of dry and critically dry years, with reductions up to 9% in June of critically dry years. In all other months and year types, changes were 1% or less. *Clear Creek downstream from Whiskeytown Dam* Storage and elevation levels in Whiskeytown Lake would be similar to the No Action Alternative with changes less than, or equal to, 2% in all months and year types. Flows in Clear Creek, downstream from Whiskeytown Dam, would be similar to the No Action Alternative with changes less than, or equal to, 1% in all months of all year types. *Sacramento River* Shasta Lake storage and elevation would be similar to the No Action Alternative with changes of less than, or equal to, 1% in all months and year types. Sacramento River flow, downstream from Keswick Dam, would be similar to the No Action Alternative with most months of all year types changing less than 1%, with the exception of a reduction of 3% in September of critical years. *Feather River* Lake Oroville storage and elevation, and Feather River flow below the Oroville Dam and Thermalito Afterbay Return, is similar to the No Action Alternative with changes of 1% or less in all months of all year types, except for an increase of 6% in river flow in June of critical years.	Environmental effects associated with changes in water storage, flows and supply may affect physical conditions in other resource categories and are related to impacts on surface water quality (as described in Chapter 5, “Surface Water Quality”), groundwater (as described in Chapter 6, “Groundwater Resources/ Groundwater Quality”), biological resources (as described in Chapter 7, “Biological Resources – Fisheries” and Chapter 8, “Biological Resources – Terrestrial”), hydropower (as described in Chapter 9, “Hydropower Generation”), agriculture (as described in Chapter 11, “Agricultural Resources”), and recreation (as described in Chapter 12, “Socioeconomics”) Mitigation measures, if needed, related to environmental changes caused by changes in surface water conditions are presented in Chapters 5, 6, 7, 8, 9, 11, and 12.

Table 4-68. Comparison of Action Alternatives to No Action Alternative (contd.)

Alternative	Potential Change	Consideration for Mitigation Measures
Alternative 2 (contd.)	*Sacramento River Flow Into the Yolo Bypass at Fremont Weir* Flows from the Sacramento River into the Yolo Bypass would be similar to the No Action Alternative, with changes less than, or equal to, 1% in all months of all water year types. *American River* Folsom Lake storage and elevation would be similar to the No Action Alternative, with changes of less than, or equal to, 1% in all months of all water year types. The American River flow, below Nimbus Dam, would be generally similar to the No Action Alternative with changes of less than 2% in all months of all water year types, except for an increase of 5% in September of critical years. *Stanislaus River* New Melones storage and elevation, and flows in the Stanislaus River downstream from Goodwin Dam, would be similar to the No Action Alternative with changes of less than 1% in all months of all year types. *San Luis Reservoir Storage* San Luis Reservoir CVP storage would be similar to the No Action Alternative with changes of less than 1% in all months of wet, above normal, below normal, and dry years and increases of 1 to 2% in most months of Critical years. San Luis Reservoir SWP storage would be similar to the No Action Alternative with changes of 1% or less in all months of all year types. San Luis Reservoir elevation would be similar to the No Action Alternative with changes of less than 1% in all months of all year types. *San Joaquin River Delta Inflow* The San Joaquin River inflow to the Sacramento-San Joaquin Delta would be similar to the No Action Alternative with changes of less than 1% in all months of all year types. *Sacramento River Delta Inflow* The Sacramento River flow at Freeport would be similar to the No Action Alternative with changes of less than 1% in all months of all year types. *Sacramento-San Joaquin Delta Outflow* The Sacramento-San Joaquin Delta outflow would be similar to the No Action Alternative with changes of 1% or less in all months of all year types.	See above

Table 4-68. Comparison of Action Alternatives to No Action Alternative (contd.)

Alternative	Potential Change	Consideration for Mitigation Measures
Alternative 2 (contd.)	*Old and Middle River Flow (OMR)* OMR would be similar to the No Action Alternative in all months and year types with change of less than 1%, except in June and July of critical years where there is an increase of 6% and a reduction of 2% respectively. This change in June of critical years is from a single critical year, 1992, with a change in OMR from -1943 cfs in the No Action to -3164 cfs in Alternative 2. This change in OMR was mainly driven by a single-month increase in Banks pumping, which in turn was driven by a slight decrease in SWP San Luis storage. CalSim II modifies exports as required in order to maintain the final OMR within regulatory limits which was -3500 cfs in this month (June). *Jones Pumping Plant (CVP Exports)* Exports at Jones Pumping Plant would be similar to the No Action Alternative with increases of 0 to 2%, except in July of critical years, where it is reduced by 4%. *Banks Pumping Plant (SWP Exports)* Banks export would be similar to the No Action Alternative with changes of 2% or less in all months and year types, except in June of critical years where it increases by 20%. The average is from a single critical year, 1992, with a change in Banks' exports from 448 cfs to 1769 cfs. This is a unique occurrence—that may not have occurred under shorter-term real-time operation decisions—and is not expected to occur on a regular basis. *CVP Delivery North of Delta* CVP North of Delta delivery would be similar to the No Action Alternative with reductions of 2% or less (critical years from 23 TAF to 22 TAF) in all year types for all water contractors/customers. *CVP Delivery South of Delta* CVP South-of-Delta delivery would be similar to the No Action Alternative with reductions of 1% or less in all year types for all contractors. *CVP Eastside Water Deliveries* CVP Eastside water deliveries would be similar to the No Action Alternative with changes to all contractors in all year types of less than 1%. *Total CVP Deliveries* Total CVP water deliveries would be similar to the No Action Alternative with changes to all contractors in all year types of less than 1%, with an average increase of 1 TAF. Changes by year type range from an increase of 4 TAF in above normal years to a decrease of 6 TAF in critical years.	See above

Key:
% = percent
cfs = cubic feet per second
CVP = Central Valley Project
ROD = Record of Decision
SWP = State Water Project
TAF = thousand acre-feet

Potential Mitigation Measures

Mitigation measures are identified, as appropriate, to avoid, minimize, rectify, reduce, eliminate, or compensate for adverse environmental effects of action alternatives, as compared to the No Action Alternative.

There are no mitigation measures proposed for direct environmental impacts from changes to CVP and SWP operational related changes in reservoir storage, elevation, downstream flows or deliveries. Impacts of these changes on other resource areas and potential mitigation measures, if required, are included in the chapters dealing with the specific resource area.

Cumulative Effects Analysis

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 surface water resources are summarized in Table 4-69. The methodology for this cumulative effects analysis is described in the Cumulative Effects Technical Appendix.

Table 4-69. Summary of Cumulative Effects on Surface Water Resources of Action Alternatives as Compared to the No Action Alternative

Scenarios	Cumulative Effects of Actions
No Action Alternative with Associated Cumulative Effects Actions in Year 2030	*Conditions and Actions included in Quantitative Analyses* *(Conditions and actions incorporated into No Action Alternative modeling)* Climate change and sea-level rise, development under the general plans, FERC relicensing projects, and some future projects to improve water quality or habitat are anticipated to reduce carryover storage in reservoirs and change timing of stream flows as compared to past conditions. In the Central Valley, Delta outflow and the availability of CVP and SWP water deliveries are anticipated to be reduced as compared to past conditions. *Additional Identified Actions* *(Additional reasonably foreseeable projects or actions identified in Cumulative Effects Technical Appendix)* Additional reasonably foreseeable actions related to improved water quality and habitat conditions (e.g., FERC relicensing projects), could affect timing of stream flows, but are not anticipated to change CVP and SWP water deliveries.
Alternative 1 with Associated Cumulative Effects Actions in Year 2030	*Alternative 1 with Conditions and Actions included in Quantitative Analyses* Implementation of Alternative 1 would result in reduced CVP water deliveries (long-term average) as compared to the No Action Alternative. *Alternative 1 with Additional Identified Actions* Additional reasonably foreseeable actions are not anticipated to result in additional cumulative reductions of CVP or SWP water deliveries.
Alternative 2 with Associated Cumulative Effects Actions in Year 2030	*Alternative 2 with Conditions and Actions included in Quantitative Analyses* Implementation of Alternative 2 would result in comparable CVP water deliveries (long-term average) as compared to the No Action Alternative. *Alternative 2 with Additional Identified Actions* The additional reasonably foreseeable actions are not anticipated to result in changes to CVP or SWP water deliveries.

Key:
CVP = Central Valley Project
FERC = Federal Energy Regulatory Commission
SWP = State Water Project

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Chapter 5
Surface Water Quality

Introduction

This chapter describes the surface water quality in the study area and potential changes that could occur as a result of implementing the alternatives evaluated in this Environmental Impact Statement (EIS). Implementation of the alternatives could affect these resources through potential changes in operation of the Central Valley Project (CVP), including the Trinity River Division (TRD), and the State Water Project (SWP), as a result of augmenting flows in the lower Klamath River.

Regulatory Environment and Compliance Requirements

Federal or State regulations relevant to implementation of the alternatives evaluated in this EIS for surface water quality include:

- **Clean Water Act** – The Federal Water Pollution Control Act Amendments of 1972, also known as the Clean Water Act (CWA), established the institutional structure for the U.S. Environmental Protection Agency (USEPA) to regulate discharges of pollutants into the waters of the United States, establish water quality standards, conduct planning studies, and provide funding for specific grant projects. The CWA was further amended through the Clean Water Act of 1977 and the Water Quality Act of 1987. The California State Water Resources Control Board (SWRCB) was designated by the USEPA along with the nine Regional Water Quality Control Boards (RWQCB) to develop and enforce water quality objectives and implementation plans in California. Section 303 requires preparation of basin plans that designate the beneficial uses of waters within each watershed basin and identify water quality objectives designed to protect the beneficial uses. Under Section 303(d), the USEPA identifies and ranks waterbodies for which existing pollution controls are insufficient to attain or maintain water quality standards based upon information prepared by all states, territories, and authorized Indian tribes. This list of impaired waters for each state comprises the state's 303(d) list.

- **Porter-Cologne Water Quality Control Act** – The Porter-Cologne Water Quality Control Act (Porter-Cologne Act) established surface water and groundwater quality guidelines and provided the authority for the SWRCB to protect the state's surface water and groundwater. Nine RWQCBs have been established to oversee and implement specific water quality activities in their geographic jurisdictions. The Porter-Cologne Act also requires that each RWQCB develop basin plans that establish and periodically review the beneficial uses and water quality objectives for groundwater and surface waterbodies within its jurisdiction.

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

Affected Environment

This section describes the surface water quality that could potentially be affected by the implementation of the alternatives considered in this EIS. Changes in water quality due to changes in the operation of the TRD (and related changes at CVP and SWP facilities) may occur in the Trinity River, lower Klamath River, Sacramento Valley, and Sacramento-San Joaquin River Delta (Delta).

Beneficial Uses of Surface Waters in the Study Area

Water quality conditions throughout the study area are assessed and described by the RWQCB Basin Plans and Integrated Reports. Each region has specific beneficial uses of surface waters (as summarized in Table 5-1) and water quality constituents of concern (e.g., nutrients, salinity, dissolved oxygen (DO)); however, several pollutants are prevalent throughout the study area. The origins and prevalence of these pollutants are discussed below.

Table 5-1. Designated Beneficial Uses Within Project Study Area

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

Table 5-1. Designated Beneficial Uses Within Project Study Area (contd.)

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

Table 5-1. Designated Beneficial Uses Within Project Study Area (contd.)

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

Table 5-1. Designated Beneficial Uses Within Project Study Area (contd.)

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

Sources: CVRWQCB 2004, SWRCB 2006, Hoopa Valley TEPA 2008, CVRWQCB 2011, NCRWQCB 2011

Notes:
E: Existing Beneficial Use; P: Potential Beneficial Use
[1] Includes beneficial uses for the Trinity River within the Hoopa Valley Indian Reservation as designated by the Hoopa Valley Indian Reservation Water Quality Control Plan, which, in addition to beneficial uses shown, also designates the Lower Trinity River as a Wild and Scenic waterway, providing for scenic, fisheries, wildlife, and recreational purposes.
[2] Not all beneficial uses are present uniformly throughout this water body. They have been summarized to reflect beneficial uses present in multiple segments of the water body.
[3] Canoeing and rafting included in REC-1 designation.
[4] Resident does not include anadromous. Any segments with both COLD and WARM beneficial use designations will be considered COLD water bodies for the application of water quality objectives.
[5] Cold water protection for salmon and steelhead.
[6] Warm water protection for striped bass, sturgeon and shad.
[7] Beneficial uses vary throughout the Delta and will be evaluated on a case-by-case basis. COMM is a designated beneficial use for the Sacramento San Joaquin Delta and Yolo Bypass waterways listed in Appendix 43 of the Basin Plan for the Sacramento River and San Joaquin River Basins and not any tributaries to the listed waterways, or portions of the listed waterways, outside of the legal Delta boundary unless specifically designated.
[8] Delta beneficial uses as shown are designated by the Water Quality Control Plan for the Sacramento River Basin and the San Joaquin River Basin, and the Water Quality Control Plan for the San Francisco Bay/Sacramento San Joaquin Delta Estuary.
[9] Per SWRCB's Resolution No. 90-28, Marsh Creek and Marsh Creek Reservoir in Contra Costa County are assigned the following beneficial uses: REC-1 and REC-2 (potential uses), WARM, WILD and RARE. COMM is a designated beneficial use for Marsh Creek and its tributaries listed in Appendix 43 of the Basin Plan for the Sacramento River and San Joaquin River Basins within the legal Delta boundary.

Water Temperature

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

- The natural receiving water temperature of intrastate waters shall not be altered unless it can be demonstrated to the satisfaction of the RWQCB that such alteration in temperature does not adversely affect beneficial uses.

- At no time or place shall the temperature of cold or warm-intrastate waters be increased by more than 5 degrees Fahrenheit (°F) above natural receiving water temperature.

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

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

Salinity

Salinity, a measure of dissolved salts in water, is a concern in the tidally-influenced Delta as it can cause impacts on domestic supply, agriculture, industry, and wildlife (CALFED 2007). The impacts of salinity on the domestic supply of water in the Delta includes aesthetic (skin or tooth discoloration), or cosmetic (taste, odor, or color) effects. There may also be a need to reduce salinity for municipal and industrial (M&I) uses via blending, which can lead to a reduction in the quantity of usable water. Salts, such as bromide, in drinking water can increase the formation of harmful byproducts. Salinity in the Delta impacts agriculture by reducing crop yields and salinity in the soil can cause plant stress. Another salt ion, chloride, in high concentrations in M&I supply has been known to cause corrosion in canned goods because of residual salts in paper boxes or linerboard that are used for packaging. The CVP and SWP are operated to achieve salinity objectives in the Delta under SWRCB Water Rights Decision 1641 (D-1641).

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

The SWRCB D-1641 includes *spring X2* criteria during February through June, and the 2008 U.S. Fish and Wildlife Service (USFWS) Biological Opinion (BO) (USFWS 2008) also includes an additional requirement in September and October in wet and above normal water years (Fall X2).

Nutrients

Nutrients are a constituent of concern in the lower Klamath River hydrologic area (Klamath Glen HSA). Nutrients (such as nitrogen and phosphorus) come from natural sources such as the weathering of rocks and soil, from the ocean when nutrients are mixed in the water current, as well as from animal manure, atmospheric deposition, and nutrient recycling in sediment (NOAA 2014; USEPA 1998). Anthropogenic sources include fertilizers, detergents, sewage treatment plants, septic systems, combined sewer overflows, and watershed sediment mobilization (USEPA 1998).

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

Dissolved Oxygen

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

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

To protect aquatic life, the USEPA has established water quality standards for DO (USEPA 1986). However, to protect the beneficial uses of California's water bodies (Table 5-1), including warm and cold freshwater habitats in both tidal and non-tidal waters, site-specific water quality objectives were established.

Lower Klamath and Trinity River Region

The Lower Klamath and Trinity River Region includes the area in Trinity County along the Trinity River, from Trinity Lake to its confluence with the Klamath River; and in Humboldt and

Del Norte Counties along the Klamath River, from the confluence with the Trinity River to the Pacific Ocean.

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

Several water quality requirements affect the Klamath River and Trinity River Basins. Beneficial uses and water quality objectives provided by the North Coast Regional Water Quality Control Board (NCRWQCB) and the Hoopa Valley Tribal Environmental Protection Agency (TEPA) are described below, as well as relevant Total Maximum Daily Loads (TMDL). The Yurok Tribe Basin Plan for the Yurok Indian Reservation and the Resighini Rancheria Tribal Water Quality Ordinance also regulate portions of the Trinity and Klamath Rivers that flow into (and through) the reservations. Because these programs have not yet been approved by the USEPA, their objectives are not described in detail here. The State of Oregon water quality requirements also affect the water quality of the Klamath River, which originates in that state. However, this chapter only discusses the requirements within the Trinity and Lower Klamath River Basins.

Beneficial Uses

Beneficial uses for all water bodies in the study area are determined by the NCRWQCB and the Hoopa Valley TEPA (Table 5-1). In addition to the beneficial uses listed in the Trinity and Klamath River Basins, the North Coast Basin Plan notes that recreational use (i.e., water contact recreation (REC-1) and non-contact water recreation (REC-2)) occurs in all hydrologic units of the Klamath River Basin—with Trinity River being one of the rivers receiving the largest levels of recreational use (NCRWQCB 2011). Fish and wildlife reside in virtually all of the surface waters within the North Coast Region (NCRWQCB 2011). This fauna includes several species that are designated as rare, threatened, and endangered. Trinity Dam also provides the beneficial use of hydroelectric power (POW).

Constituents of Concern

The constituents of concern that are currently not in compliance with existing water quality standards and for which TMDLs are adopted (or are in development) are summarized in Table 5-2.

Table 5-2. Constituents of Concern per the 303(d) List Within the Klamath River Region

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

Source: SWRCB 2011a
Note:
[1] TMDL status is either expected to be completed or approved by USEPA in the year specified.
Key:
DO = Dissolved Oxygen
HU = Hydrologic Unit
HA = Hydrologic Area
HAS = Hydrologic Sub-Area
TMDL = Total Maximum Daily Load

Water Temperature Elevated water temperature in the project area is addressed through objectives and criteria specified for individual reaches. For example, not all reaches of the Trinity and Klamath Rivers are listed on the 303(d) list approved by the USEPA in 2010 as impaired by water temperature. However, the hydrologic area of the South Fork Trinity River and the lower hydrologic area of the Klamath River (Klamath Glen HSA), are listed for elevated water temperatures adversely affecting the cold freshwater habitat (SWRCB 2011b-g).

Further, the North Coast Basin Plan designates narrative and numeric water temperature objectives—applicable to surface waters throughout the Trinity River and the Lower Klamath River Basins—to protect and support resident and seasonal fish species habitats. Other objectives and criteria specific to each region are specified below.

Trinity River Water temperature objectives (summarized in Table 5-3) were set forth in the North Coast Basin Plan specifically applicable to the Trinity River, from Lewiston Dam to Douglas City and to the confluence with the North Fork Trinity River. These criteria are reach dependent, and vary seasonally. They were developed to enhance the productivity of the Trinity River Fish Hatchery, specifically for salmon and steelhead trout populations (NCRWQCB 2011).

The South Fork Trinity River is listed on the 303(d) list approved by the USEPA in 2010 for elevated water temperatures. This stream flows from its headwaters to its confluence with the mainstem of the Trinity River (approximately 30 miles upstream of its confluence with the Klamath River), and supports steelhead, Chinook Salmon, and Coho Salmon (below Grouse Creek) (USDAFS 2014). Elevated water temperatures in the South Fork Trinity River can be attributed to the loss of shade trees due to habitat modification, range grazing, removal of riparian vegetation, streambank modification and destabilization, and water diversions (SWRCB 2011c). Development of a temperature TMDL has not been scheduled for the South Fork Trinity River at this time.

Table 5-3. Water Quality Objectives for Temperature in the Trinity River

Source	Target Reach	Dates	Temperature Target
North Coast Regional Water Quality Control Board Basin Plan[1]	• Lewiston to Douglas City	All Years • July 1 to September 15	≤ 60° F
SWRCB's Order WR-90-5[2]	• Lewiston to Douglas City	• September 16 – 301	≤ 56° F
	• Lewiston to the confluence with the North Fork Trinity River	• October 1 to December 311	≤ 56° F
Springtime Objectives of the Record of Decision for the Trinity River Mainstem Fisheries Restoration EIS/EIR[3]	Lewiston to Weitchpec	Normal and Wetter Water Years • April 15 to May 22 • May 23 to June 4 • June 5 to July 9	 ≤ 55° F ≤ 59° F ≤ 62.5° F
		Dry and Critically Dry Water Years • April 15 to May 22 • May 23 to June 4 • June 5 to June 15	 ≤ 59° F ≤ 62.5° F ≤ 68° F

Sources:
[1] NCRWQCB 2011
[2] SWRCB 1990
[3] DOI and Hoopa Valley 2000; USFWS et al. 2000
Key:
EIR = Environmental Impact Report
EIS = Environmental Impact Statement
SWRCB=California State Water Resources Control Board

Hoopa Valley Indian Reservation Natural causes of temperature exceedances—such as unusually excessive ambient meteorological conditions coupled with seasonal low flows, intended to protect aquatic habitat specified in the Trinity River Flow Evaluation Report (TRFE) (USFWS and Hoopa Valley Tribe 1999)—will not be considered to violate the water quality objectives stated in the Hoopa Valley Indian Reservation Basin Plan.

Temperature objectives for the Trinity River (as it passes through the Hoopa Valley Reservation) vary seasonally and are hydrologically year type dependent (Table 5-4).

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

Table 5-4. Trinity River Temperature Criteria for the Hoopa Valley Indian Reservation

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

Source: Adapted from Hoopa Valley TEPA 2008

Notes:

[1] Temperature standards will be monitored at the Weitchpec temperature monitoring station operated and maintained by the U.S. Department of the Interior, Bureau of Reclamation.

[2] Temperature standard violations will be determined if more than 10 percent of 7-day running averages exceed the standard, to be determined by the number of days exceeded for that seasonal period (i.e., for June 16 – September 14, a 91 day period, 10 percent exceedance will equate to 9 days).

[3] For the seasonal period of June 16 – September 14, temperatures on the mainstem Trinity River at the Weitchpec gauging station were used to determine running 7-day averages.

Key:

ºF = degrees Fahrenheit

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

In addition to the seasonal water temperature criteria, the Hoopa Valley TEPA has established varying criteria for each life stage of salmonids (Table 5-5).

Table 5-5. Tributary Temperature Criteria for the Hoopa Valley Indian Reservation

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

Source: Adapted from Hoopa Valley TEPA 2008

Notes:

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

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

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

Key:

ºF = degrees Fahrenheit

As shown in Table 5-6 and Figure 5-1, water temperature data for the Trinity River, between 2001 and 2015, show seasonal trends and the warming effect of ambient conditions at the downstream location. Compliance locations for water quality monitoring along the Trinity River are shown in Figure 5-2. Monitoring of water temperatures of the Trinity River on the Hoopa Valley Tribal reservation occurs at the U.S. Geological Service gage (Gage # 11530000).

Table 5-6. Monthly Average of Water Temperatures Recorded at Trinity River Compliance Locations

WY	WYT	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Douglas City													
2001	D	51.9	46.6	44.2	42.0	43.2	47.5	50.7	54.4	55.5	58.5	57.0	54.2
2002	N	51.0	47.7	42.7	43.1	43.8	46.6	52.5	49.4	56.1	58.9	56.2	54.4
2003	W	49.8	46.5	44.6	44.9	44.8	48.0	48.8	50.4	52.8	57.0	56.6	52.7
2004	W	51.2	46.6	43.7	41.5	43.7	47.5	51.4	50.3	51.4	54.9	56.4	53.0
2005	W	50.9	47.4	42.9	42.8	45.3	48.2	50.8	49.9	52.2	57.9	59.5	54.7
2006	EW	51.5	47.4	43.9	45.5	44.4	44.2	47.5	48.4	49.3	54.9	NA	NA
2007	D	NA	NA	43.0	39.5	43.1	48.4	52.5	47.9	55.8	58.7	57.2	54.1
2008	D	50.3	46.9	41.8	39.5	41.2	46.4	50.0	48.6	50.8	53.4	58.0	55.3
2009	D	51.4	49.3	43.5	43.0	43.4	46.8	51.7	50.9	56.6	60.5	58.1	55.9
2010	W	51.2	47.5	42.2	44.3	45.2	46.8	48.4	48.4	52.3	57.3	58.5	55.1
2011	W	51.4	46.7	44.4	42.3	42.6	45.2	48.8	47.7	50.4	54.4	57.6	53.9
2012	N	50.5	45.5	41.2	40.2	43.5	45.2	48.9	49.3	50.9	55.2	55.6	52.4
2013 – 2015	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Trinity River above North Fork Trinity													
2001 – 2004	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2005	W	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	64.5	58.2
2006	EW	53.4	47.8	44.0	45.7	44.8	44.9	48.3	49.6	51.4	59.0	NA	NA
2007	D	NA	NA	42.5	39.6	43.5	48.9	53.2	49.3	59.8	65.4	63.0	58.3
2008	D	52.5	48.3	42.0	40.6	42.3	46.6	50.1	50.1	53.2	56.7	62.8	59.2
2009	D	53.3	49.6	43.0	42.5	43.4	47.0	51.8	52.6	59.7	66.0	62.9	60.0
2010	W	53.4	47.7	41.9	44.8	45.9	47.1	48.4	49.4	53.7	60.9	63.3	59.0
2011	W	53.9	47.1	45.1	43.1	43.0	45.2	45.5	NA	NA	NA	NA	NA
2012	N	52.8	46.4	40.9	39.9	43.8	45.1	49.1	50.6	53.3	59.3	60.3	55.9
2013	D	53.8	48.5	43.1	40.4	42.4	48.6	52.2	51.8	59.0	64.9	60.9	56.7
2014	CD	51.5	46.7	39.6	41.5	44.8	49.0	53.4	55.4	60.6	65.7	63.3	58.4
2015	D	55.6	51.1	47.8	44.4	47.8	51.9	55.1	53.5	62.1	66.9	60.8	57.6
Weitchpec													
2001	D	57.9	48.2	44.8	41.9	43.5	48.8	52.1	60.9	65.8	73.8	72.1	67.0
2002	N	59.3	51.2	46.0	44.7	45.8	47.4	53.9	55.9	66.1	73.6	71.1	67.2
2003	W	57.5	49.1	46.7	49.3	50.8	54.2	54.8	58.6	69.5	70.2	71.3	64.6
2004	W	59.7	50.4	46.3	45.3	46.8	53.5	58.7	56.6	62.3	70.4	72.1	64.4
2005	W	58.6	49.9	45.0	44.3	46.7	50.0	51.5	54.6	59.5	69.8	73.0	64.9
2006	EW	58.8	50.6	46.4	48.8	47.5	47.8	50.2	53.8	57.1	65.2	NA	NA
2007	D	NA	NA	47.9	44.9	48.3	52	56.2	56.3	66.6	73.2	72.6	NA
2008 – 2015	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Source: DWR 2016

Note: WYT is Trinity Water Year Type.

Key:

CD = Critically Dry

D = Dry

EW = Extremely Wet

N = Normal

W = Wet

WY = Water year

WYT = Water Year Type

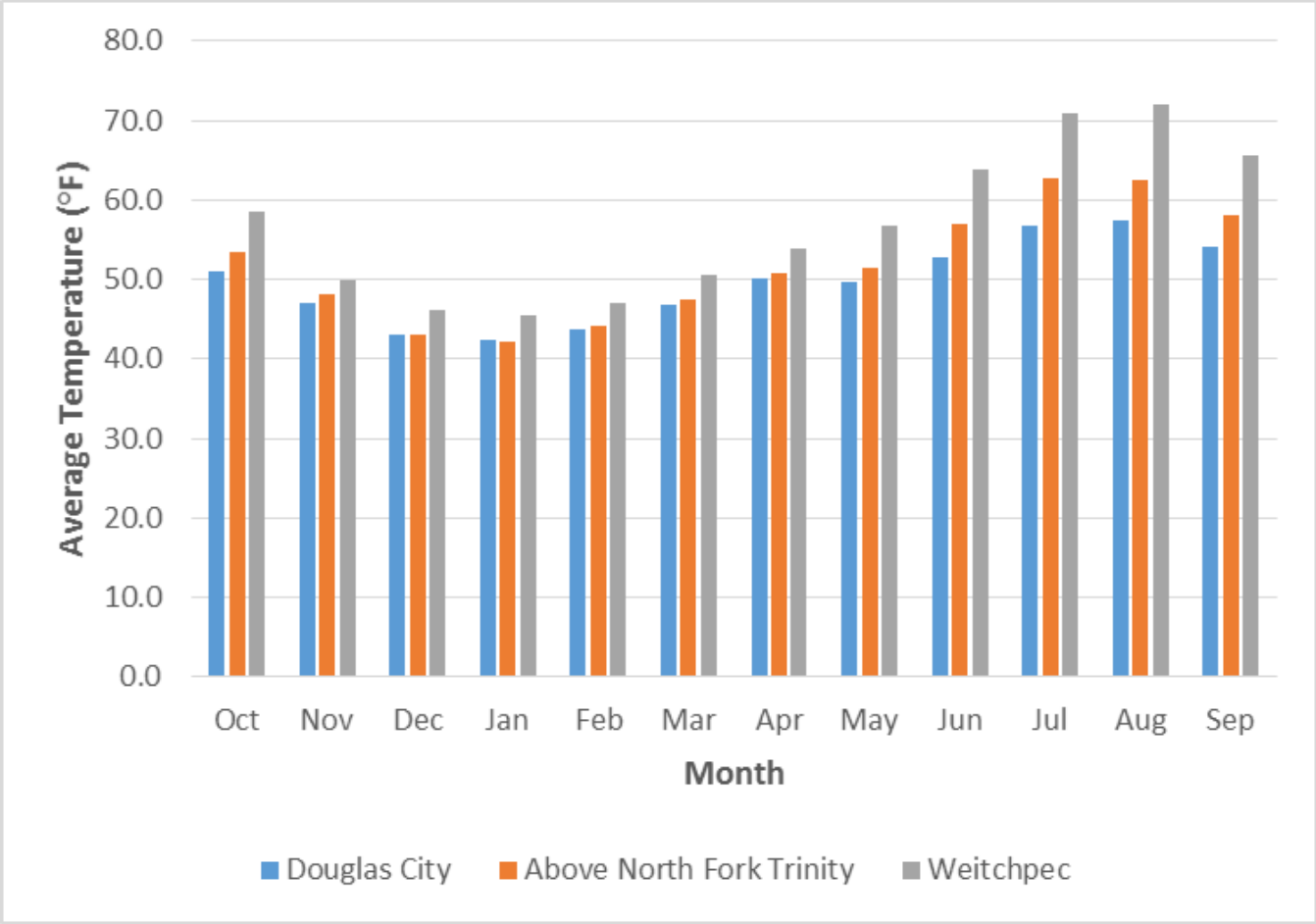


Figure 5-1. Monthly Average of Water Temperatures Recorded at Trinity River Compliance Locations (2001-2015)

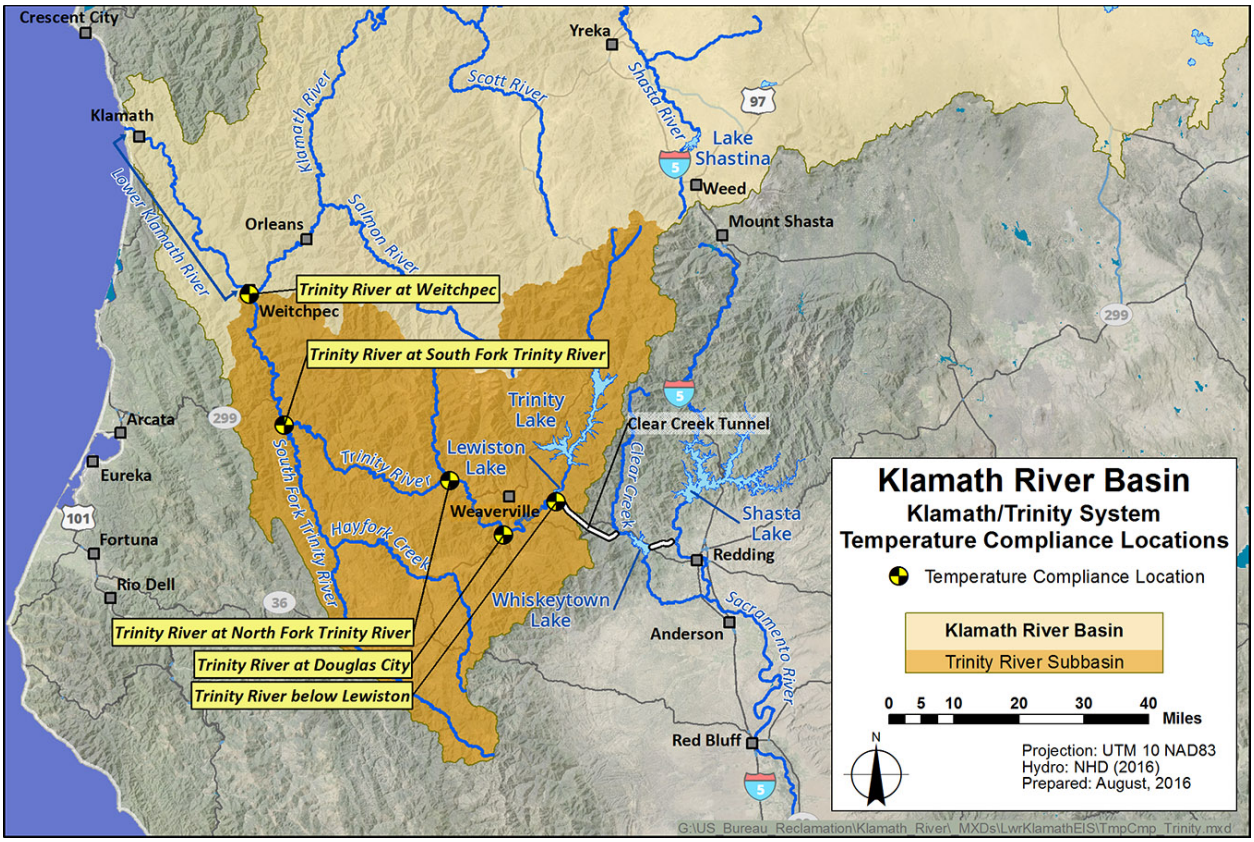


Figure 5-2. Temperature Compliance Stations Along the Trinity River

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

Nutrients The lower Klamath River was placed on the 303(d) list approved by the USEPA in 2010 for being impaired by nutrients (SWRCB 2011a). Nutrient levels in the Klamath River and Klamath River Estuary can promote levels of algal growth that cause a nuisance, or adversely affect beneficial uses, when excess growth is not consumed by animals or exported by flows (DOI and DFG 2012). The Klamath River receives the greatest nutrient loading from the Upper Klamath Basin, comprising approximately 40 percent of its total load (NCRWQCB 2010). Tributaries to the Klamath River are the greatest contributors of the remaining nutrient loads, with the Trinity River contributing the most. The Hoopa Valley TEPA also designates water quality objectives to address contamination by nutrients as shown in Table 5-7.

Table 5-7. Specific Use Water Quality Criteria for Waters of the Hoopa Valley Indian Reservation

Contaminant	Trinity River	Klamath River
Maximum Annual Periphyton Biomass	Not Applicable	150 mg chlorophyll streambed area (per m^2)
pH	MUN-designated waters: 5.0 – 9.0 All other designated uses: 7.0 – 8.5	7.0 – 8.5
Total Nitrogen[1]	Not Applicable	0.2 mg/l
Total Phosphorus[1]	Not Applicable	0.035 mg/l
Microcystis aeruginosa cell density	Not Applicable	< 5,000 cells/mL for drinking water < 40,000 cells/mL for recreational water
Microcystin toxin concentration	Not Applicable	< 1 µg/l total microcystins drinking water < 8 µg/l total microcystins recreational water
Total potentially toxigenic blue-green algal species[2]	Not Applicable	< 100,000 cells/mL for recreational water
Cyanobacterial scums	Not Applicable	There shall be no presence of cyanobacterial scums

Source: Hoopa Valley TEPA 2008

Notes:

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

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

Key:

µg/l = microgram per liter

m^2 = square meter

mg/l = milligram per liter

mL = millimeter

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

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

The Klamath Hydroelectric Settlement Agreement Interim Measure 15 (IM 15) - Water Quality Monitoring (funded by PacifiCorp) supports long-term baseline water quality monitoring to assist in water quality improvement activities, dam removal studies, permitting studies, and to form a long-term record to assess trends and other potential changes in the Basin (PacifiCorp 2011a, 2011b, 2012, 2013, 2014, 2015, 2016). Monitoring is performed by the Yurok Tribe, Karuk Tribe, PacifiCorp, and Reclamation. The program collects data from 254 miles of river and reservoirs from Link Dam (near Klamath Falls in Oregon) to the Klamath River Estuary in

California. The program has been in place since 2009. Available field observations from the IM 15 program for pH, TN and TP for the Trinity River (above the Klamath River) and Klamath River (near Klamath) are shown in Figure 5-3 through Figure 5-5, respectively.

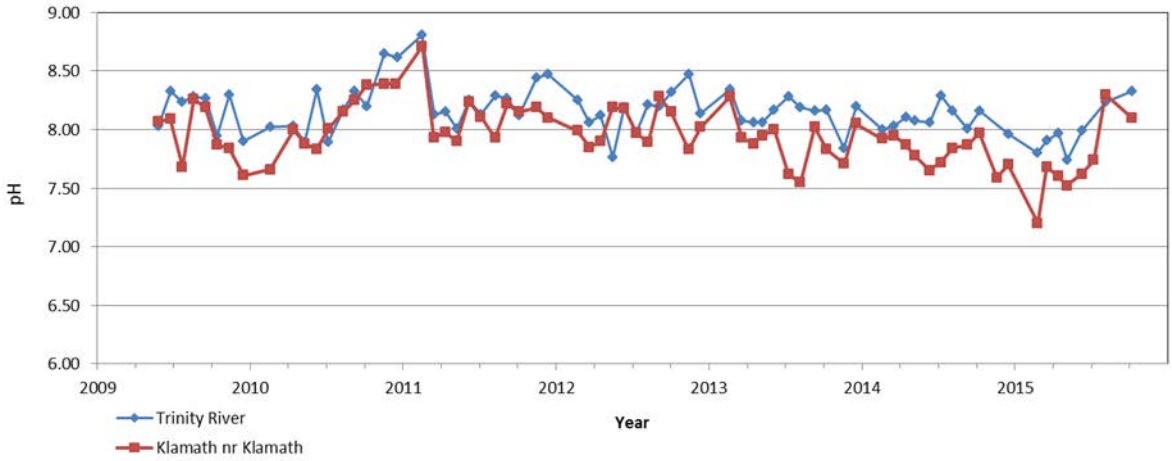


Figure 5-3. pH at Trinity River Above the Klamath River and Klamath River Near Klamath for 2009-2015

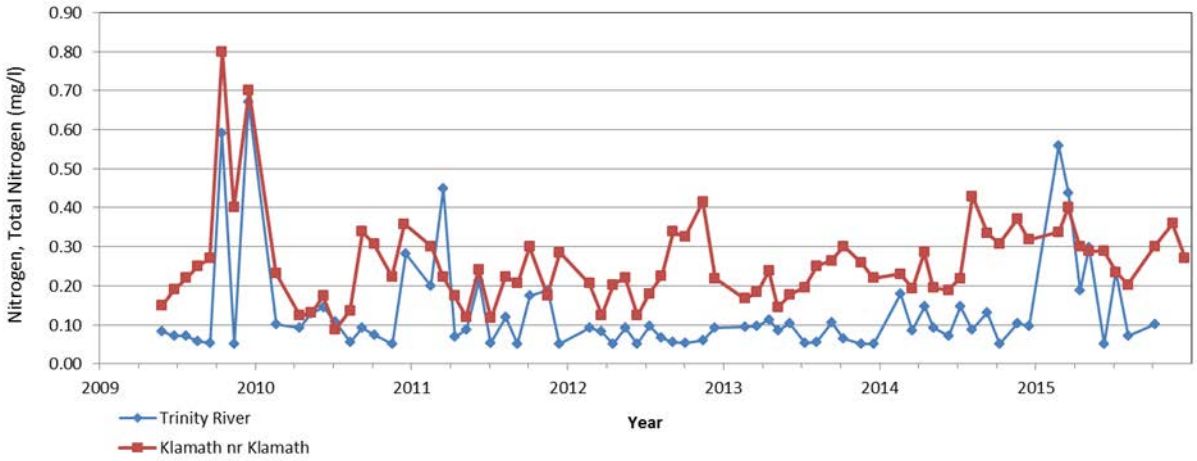


Figure 5-4. Total Nitrogen at Trinity River Above the Klamath River and Klamath River Near Klamath for 2009-2015

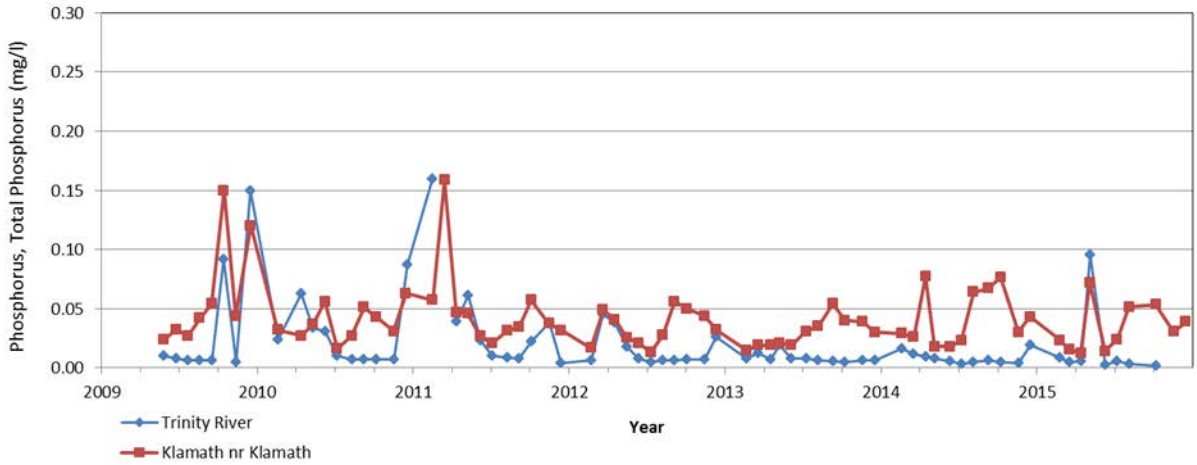


Figure 5-5. Total Phosphorus at Trinity River Above the Klamath River and Klamath River Near Klamath for 2009-2015

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

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

Growth of blue-green algae can contribute to nuisance conditions such as: extreme diurnal DO and pH fluctuations due to the effect of photosynthesis and respiration of the algal biomass, high concentrations of cyanotoxins produced by toxigenic blue-green algal species, DO crashes due to the decomposition of decaying algal biomass, and in extreme conditions, disruption of food webs. Blue-green algae thrive under warm water temperature, high nutrient, and stable water column conditions (Konopka and Brock 1978, Kann 2006) where they can out-compete other algal species such as diatoms. As such, they are largely restricted to impounded reaches or backwater areas that provide appropriate conditions. Algae, including blue-green algae can wash out of reservoirs and be found in downstream reaches, typically in notably lower numbers than occur in lentic environments.

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

matter allocations were also established for the Klamath River below the Salmon River, and the major tributaries to the Klamath, including the Trinity River.

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

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

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

To protect the beneficial uses of the lower Klamath River, including the cold freshwater habitat, water quality objectives were established in the North Coast Basin Plan (2010) and the Hoopa Valley TEPA (2008) for DO in the Klamath River and its major tributary, the Trinity River (Table 5-8 and Table 5-9) (NCRWQCB 2011). Site Specific Objectives for DO were calculated as part of TMDLs developed by the NCRWQCB (2011), and have been incorporated into the North Coast Basin Plan (2011) (Table 5-10). For those waters without location-specific DO criteria, DO shall not be reduced below minimum levels (shown in Table 5-11) at any time in order to protect beneficial uses.

Table 5-8. Water Quality Objectives for Dissolved Oxygen in Trinity and Lower Klamath

Water Body	Dissolved Oxygen (milligrams per liter) Minimum	50% Lower Limit[1]
Trinity Lake and Lewiston Reservoir	7.0	10.0
Lower Trinity River	8.0	10.0
Lower Trinity Area Streams	9.0	10.0
Lower Klamath River Area Streams	8.0	10.0

Source: NCRWQCB 2011

Note:

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

Key:

% = percent

Table 5-9. Specific Use Water Quality Criteria for Waters of the Hoopa Valley Indian Reservation

Contaminant	Trinity River	Klamath River
Minimum Water Column DO Concentration	11.0 mg/l	SPWN-designated waters1: 11.0 mg/l[2] COLD-designated waters: 8.0 mg/l[2]
Minimum Inter-gravel DO Concentration	8.0 mg/l	SPWN-designated waters1: 8.0 mg/l[2]

Source: Hoopa Valley TEPA 2008

Notes:

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

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

Key:

DO = dissolved oxygen

mg/l = milligram per liter

Table 5-10. Site Specific Objectives for Dissolved Oxygen in the Klamath River[1]

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

Source: NCRWQCB 2011

Notes:

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

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

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

Key:

% = percent

DO = dissolved oxygen

Table 5-11. Water Quality Objectives for Dissolved Oxygen for Specified Beneficial Uses

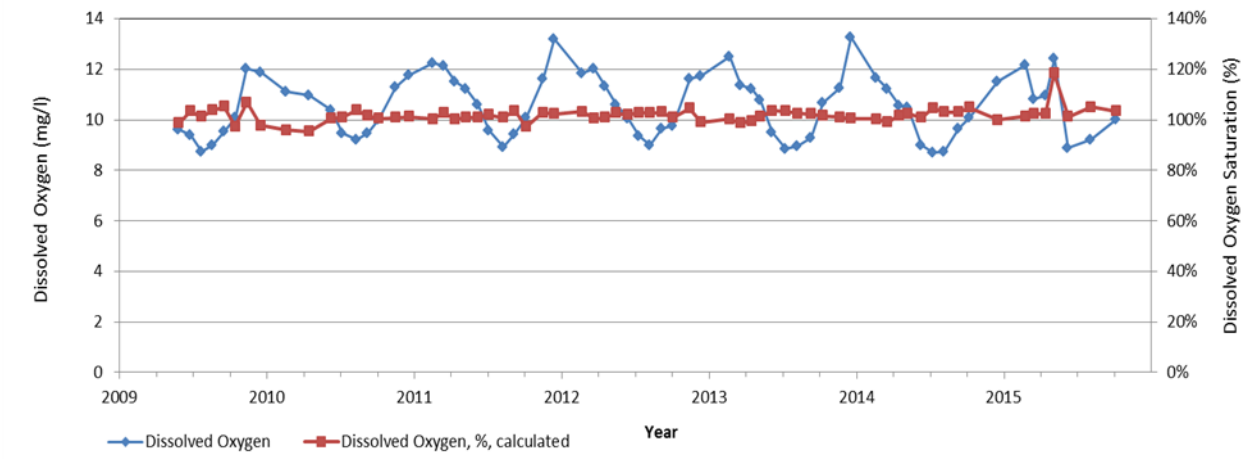
Beneficial Use Designation	Minimum Dissolved Oxygen Limit (mg/l)
WARM, MAR, or SAL	5.0
COLD	6.0
SPWN	7.0
SPWN – during critical spawning and egg incubation periods	9.0
Klamath River Water Column[1] SPWN-designated waters:[2] COLD-designated waters:	 11.0 mg/l[3] 8.0 mg/l[3]
Klamath River Inter Gravel[1]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

Source: NCRWQCB 2011
Key:
COLD = Cold Freshwater Habitat
MAR = Marine Habitat
mg/l[3] = milligram per cubic liter
SAL = Inland Saline Water Habitat
SPWN = Spawning, Reproduction, and/or Early Development
WARM = Warm Freshwater Habitat

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

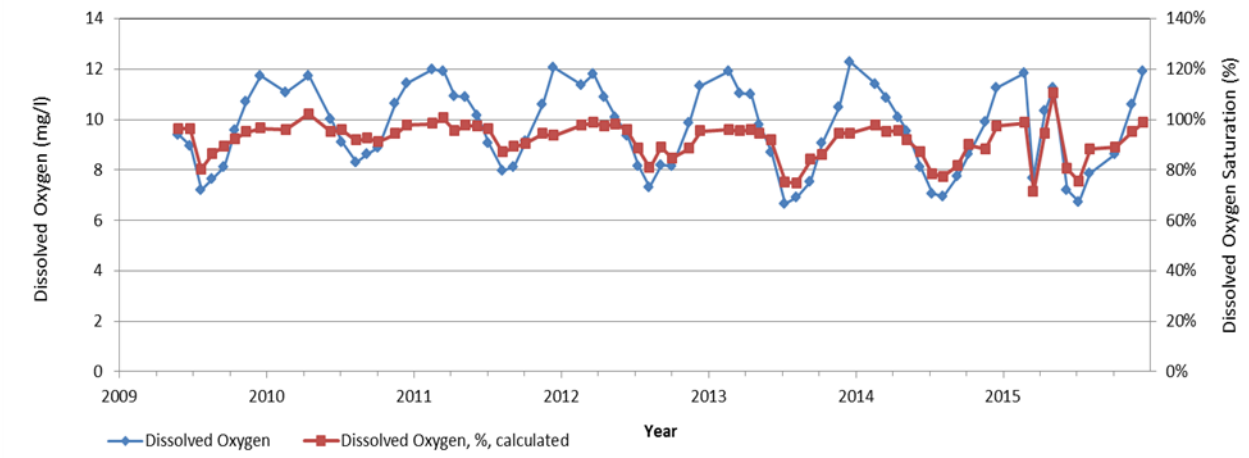
Plans to monitor DO and other constituents in the Klamath River (below Trinity River, near Turwar) and the Klamath River Estuary were established in Chapter 7 of the Klamath River TMDLs, to further protect the beneficial uses of the Trinity and lower Klamath Rivers (NCRWQCB 2010). The TMDL also includes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

Available field observations from the IM 15 program for DO concentration and percent saturation for the Trinity River above the Klamath River and Klamath River near Klamath are shown in Figure 5-6 and Figure 5-7.



Key:
% = percent
mg/l = milligrams per liter

Figure 5-6. Dissolved Oxygen Concentration and Percent Saturation for the Trinity River Above the Klamath River for 2009-2015



Key:
% = percent
mg/l = milligrams per liter

Figure 5-7. Dissolved Oxygen Concentration and Percent Saturation for the Klamath River Near Klamath for 2009-2015

Central Valley and Bay-Delta Region

The Central Valley and Bay-Delta Region includes the major rivers and waterways downstream of CVP and SWP dams and reservoirs.

Sacramento Valley

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

Beneficial uses of surface waters for the Sacramento Valley (as defined in the Central Valley Basin Plan) are summarized in Table 5-1. The constituents of concern that are currently not in compliance with existing water quality standards, and for which TMDLs are adopted or are in development in this region.

Sacramento River from Shasta Lake to Verona Water quality in the upper Sacramento River is influenced by releases from Shasta Lake and diversions from Trinity Lake. Annual and seasonal flows in the Sacramento River watershed are highly variable from year to year, as described in Chapter 4, "Surface Water Supply and Management." These variations in flow are a source of variability in water quality in the Sacramento River drainage.

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

Water Temperature The Sacramento River was not placed on the 303(d) list approved by the USEPA in 2010 as impaired by water temperature (SWRCB 2011a). However, water bodies in the upper Sacramento River watershed support the beneficial uses of both warm and cold freshwater habitat, which require that the water bodies maintain water temperatures suitable for multiple fish species (CVRWQCB 2011). Water quality objectives have been established by the SWRCB for the Sacramento River, as summarized in Table 5-12. Performance measures to meet these temperature requirements from May 15-Oct 31 are included in the 2009 NMFS BO (NMFS 2009), and are shown in Table 5-13. An additional objective in the 2009 NMFS BO, not shown in Table 5-13, is that temperatures must be maintained at <56 ºF during April 15-May 15 from Balls Ferry to Bend Bridge. All of these objectives are for winter- and spring-run Chinook Salmon spawning and egg incubation. Finally, there is a temperature objective at Bend Bridge of <63 ºF for Green Sturgeon spawning, incubation and rearing (Reclamation 2015). Temperature conditions on the Sacramento River are managed through operation of the temperature control device at Shasta Dam, and are also affected by imports from the Trinity Basin. Compliance locations in the upper Sacramento River Basin are shown in Figure 5-8.

Table 5-12. Water Quality Objectives for Temperature in the Sacramento River

Applicable Water Bodies	Objective
Sacramento River at Hamilton City	< 56ºF
Sacramento River from Hamilton City to the I Street Bridge (during periods when temperature increases will be detrimental to the fishery)	< 68ºF

Source: CVRWQCB 2011
Key:
ºF = degrees Fahrenheit

Table 5-13. Sacramento River Temperature Performance Measures Under 2009 National Marine Fisheries Services Biological Opinion Reasonable and Prudent Alternative I.2.1

Compliance Location	Compliance Percentage (percent of days from May 15-Oct 31 with Temperatures < 56ºF)[1]
At Clear Creek	95%
Balls Ferry	85%
Jellys Ferry	40%
Bend Bridge	15%

Note:
[1] Percentage is calculated as a 10-year running average excluding years of extended droughts.
Key:
% = percent
ºF = degrees Fahrenheit

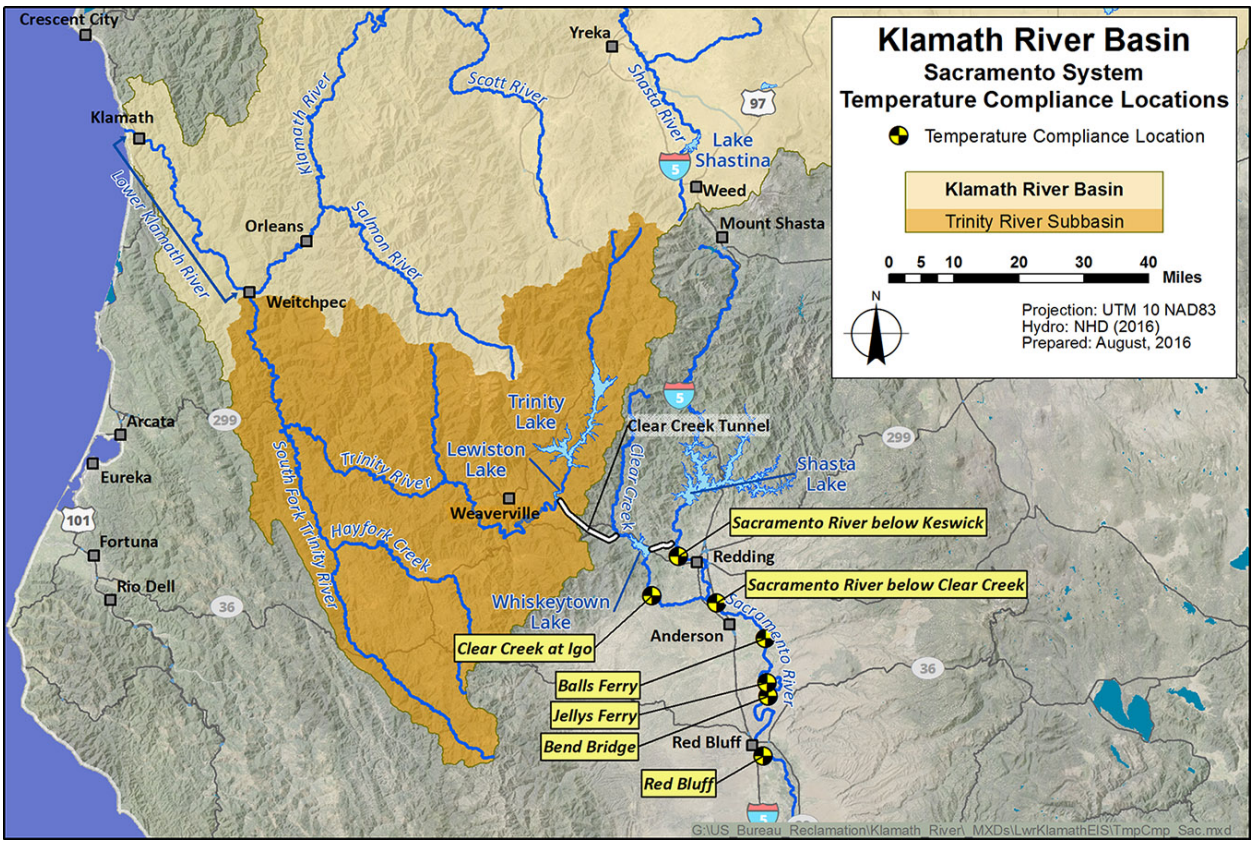


Figure 5-8. Temperature Compliance Stations in the Upper Sacramento River Basin

Table 5-14 and Figure 5-9 depict monthly water temperature data at selected compliance locations in the Sacramento River between 2001 and 2015.

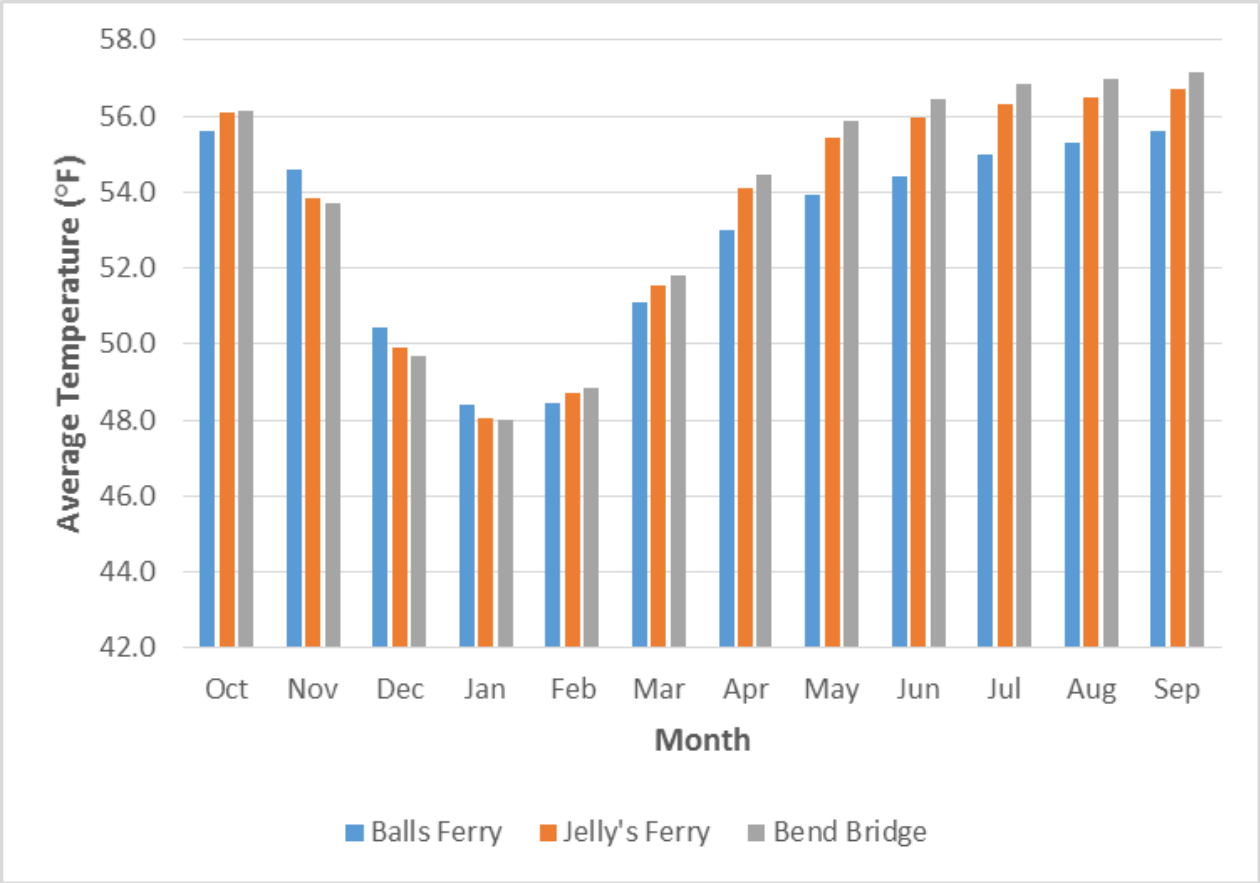
Table 5-14. Monthly Average of Water Temperatures Recorded at Sacramento River Compliance Locations in °F

WY	WYT	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Balls Ferry													
2001	D	55.0	53.2	51.4	47.9	47.0	51.5	52.5	52.9	53.6	54.5	54.3	55.3
2002	D	56.1	54.3	50.0	49.4	48.8	50.5	53.9	53.7	53.7	54.4	54.4	54.0
2003	AN	54.4	54.2	50.0	49.6	49.3	51.7	53.2	53.3	53.5	53.6	54.9	55.4
2004	BN	54.7	52.6	50.2	48.3	47.6	50.9	52.5	53.0	53.7	54.5	54.6	56.7
2005	AN	56.5	54.9	50.6	48.8	50.0	52.1	54.1	54.2	53.5	54.0	55.4	55.6
2006	W	56.2	54.5	50.5	ND	47.8	47.7	49.7	52.7	52.8	53.6	53.8	53.5
2007	D	53.4	52.4	49.7	47.7	48.4	52.0	54.0	52.9	53.8	55.2	55.1	55.7
2008	C	55.9	55.3	50.1	45.7	46.8	49.8	50.9	52.9	55.6	56.0	56.4	57.0
2009	D	58.1	55.8	50.1	47.5	47.8	50.6	51.6	53.8	55.0	56.0	56.0	56.5
2010	BN	56.5	55.1	49.4	48.3	49.6	50.9	52.5	54.0	53.5	53.9	54.2	54.2
2011	W	54.0	51.3	51.2	49.2	48.0	48.8	51.8	54.1	53.6	53.6	54.3	54.0
2012	BN	53.1	51.2	49.6	48.1	48.6	49.6	53.6	54.5	53.4	53.6	54.0	54.1
2013	D	53.6	53.2	49.5	46.6	48.2	50.9	54.8	54.7	54.7	56.0	55.6	54.5
2014	C	55.5	52.8	49.0	48.9	50.1	53.4	55.0	55.7	56.8	57.0	57.9	59.7
2015	C	61.2	68.0	55.1	51.8	ND	56.0	55.2	56.7	59.0	59.0	58.5	57.8
Jellys Ferry													
2001	D	55.5	52.9	51.1	47.5	47.0	52.3	53.6	54.5	54.7	55.6	55.6	56.3
2002	D	56.7	54.4	49.1	47.9	48.6	51.0	55.4	55.1	55.1	55.6	55.5	55.1
2003	AN	54.9	54.1	50.3	50.0	49.0	52.4	53.4	54.5	55.4	55.0	56.0	56.6
2004	BN	55.3	52.5	50.0	47.9	48.1	52.0	54.0	54.7	55.1	55.5	55.8	57.5
2005	AN	56.8	54.6	50.2	48.4	50.3	52.8	55.3	55.6	55.3	55.6	56.7	56.5
2006	W	56.5	54.3	49.9	49.1	48.3	47.9	50.7	54.6	54.8	55.1	55.0	54.6
2007	D	54.2	52.6	49.0	47.1	48.7	52.8	55.0	54.2	54.9	56.6	56.6	56.6
2008	C	56.3	55.4	49.6	45.4	47.0	50.5	52.2	54.5	56.6	56.9	57.3	58.0
2009	D	58.0	55.8	49.8	47.4	47.9	51.2	53.3	55.7	56.4	57.1	57.0	57.8
2010	BN	57.1	54.9	48.9	48.0	49.7	51.7	53.3	55.2	55.4	55.6	55.3	55.2
2011	W	54.6	51.3	50.9	48.9	47.8	48.7	52.2	55.3	55.2	55.0	55.4	55.2
2012	BN	53.7	51.2	49.1	48.1	48.8	49.9	54.4	56.0	54.8	54.6	55.1	55.3
2013	D	54.4	53.3	48.8	46.1	48.1	51.5	55.7	55.7	55.8	57.1	56.8	56.7
2014	C	55.7	52.9	49.1	48.8	49.9	53.3	56.8	57.6	58.8	58.7	59.1	60.7
2015	C	61.4	57.5	52.5	50.0	51.8	54.8	56.5	58.2	61.1	60.9	60.0	58.8
Bend Bridge													
2001	D	55.7	52.8	50.8	47.3	47.0	52.6	54.1	55.0	55.1	56.0	56.0	56.8
2002	D	56.9	54.4	49.0	48.1	48.9	51.2	55.8	55.6	55.6	56.0	56.2	55.6
2003	AN	55.1	53.9	50.2	50.0	49.0	52.6	53.8	54.7	55.9	55.4	56.7	57.0
2004	BN	55.5	52.3	49.4	48.0	48.2	52.2	54.2	55.5	55.6	56.1	56.2	57.9
2005	AN	57.0	54.4	50.0	48.3	50.4	53.1	55.7	55.9	55.5	56.0	57.2	56.9
2006	W	56.6	54.2	50.0	49.2	48.4	48.0	50.7	54.9	55.1	55.6	55.4	54.9
2007	D	54.4	52.3	49.1	46.9	48.8	52.9	55.1	54.9	55.5	56.6	56.6	57.0
2008	C	56.1	55.1	49.3	45.6	47.1	51.0	52.6	55.0	57.4	57.5	57.9	58.5
2009	D	57.4	55.8	49.4	47.3	48.1	52.0	53.6	56.1	56.9	57.7	57.2	58.0
2010	BN	57.0	54.8	48.6	47.9	49.6	51.6	53.3	55.4	55.5	56.2	56.2	55.8
2011	W	54.4	51.0	50.7	49.0	48.0	49.0	52.5	55.7	55.6	55.8	56.2	55.6
2012	BN	53.9	51.3	48.8	47.9	48.9	49.9	54.8	56.5	55.4	55.1	55.5	55.8
2013	D	54.7	53.3	48.6	46.0	48.3	52.1	56.0	55.9	56.3	57.4	57.1	57.2
2014	C	55.8	53.0	48.7	48.6	50.1	53.7	57.5	58.2	59.3	59.3	59.7	61.1
2015	C	61.4	57.1	52.5	49.9	52.1	55.2	57.1	58.8	61.9	61.8	60.7	59.4

Sources: Reclamation 2013 and DWR 2016

Note: WYT is Sacramento 40-30-30 Index.

Key:
AN = Above Normal
BN = Below Normal
C = Critically Dry
D = Dry
W = Wet
WY = Water year
WYT = Water Year Type



Key:
ºF = degrees Fahrenheit

Figure 5-9. Monthly Average of Water Temperatures Recorded at Sacramento River Compliance Locations (2001-2015)

Clear Creek from Whiskeytown Dam to the Confluence with the Sacramento River Lower Clear Creek (below Whiskeytown Dam) is 303(d) listed as impaired for mercury, due to mine tailings from gold mining during the 1800s. Otherwise, water quality is considered very good and supportive of all aquatic life and recreational uses (SRWP 2016).

Water Temperature Water temperatures in Lower Clear Creek are influenced by operations of Whiskeytown Dam (including the Spring Creek Temperature Control Curtain) and transfer of water from Trinity Lake to Whiskeytown Lake via the Clear Creek Tunnel. Temperature objectives for Clear Creek below Whiskeytown Dam were originally established in the 2004 CVP/SWP Operations Criteria and Plan (OCAP) (Reclamation 2004) and re-affirmed in the 2009 NMFS BO (NMFS 2009). The standards for daily water temperatures are:

- 60ºF at the Igo gage June 1-Sept 15
- 56ºF at the Igo gage Sept 15-Oct 31

Table 5-15 and Figure 5-10 depict monthly water temperature data at the Igo gage on Clear Creek from 2001 to 2015.

Table 5-15. Monthly Average of Water Temperatures Recorded at Clear Creek at Igo (2001-2015)

WY	WYT	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Clear Creek at Igo													
2001	D	55.0	53.2	51.4	47.9	47.0	51.5	52.5	52.9	53.6	54.5	54.3	55.3
2002	D	56.1	54.3	50.0	49.4	48.8	50.5	53.9	53.7	53.7	54.4	54.4	54.0
2003	AN	54.4	54.2	50.0	49.6	49.3	51.7	53.2	53.3	53.5	53.6	54.9	55.4
2004	BN	54.7	52.6	50.2	48.3	47.6	50.9	52.5	53.0	53.7	54.5	54.6	56.7
2005	AN	56.5	54.9	50.6	48.8	50.0	52.1	54.1	54.2	53.5	54.0	55.4	55.6
2006	W	56.2	54.5	50.5	ND	47.8	47.7	49.7	52.7	52.8	53.6	53.8	53.5
2007	D	53.4	52.4	49.7	47.7	48.4	52.0	54.0	52.9	53.8	55.2	55.1	55.7
2008	C	55.9	55.3	50.1	45.7	46.8	49.8	50.9	52.9	55.6	56.0	56.4	57.0
2009	D	58.1	55.8	50.1	47.5	47.8	50.6	51.6	53.8	55.0	56.0	56.0	56.5
2010	BN	56.5	55.1	49.4	48.3	49.6	50.9	52.5	54.0	53.5	53.9	54.2	54.2
2011	W	54.0	51.3	51.2	49.2	48.0	48.8	51.8	54.1	53.6	53.6	54.3	54.0
2012	BN	53.1	51.2	49.6	48.1	48.6	49.6	53.6	54.5	53.4	53.6	54.0	54.1
2013	D	53.6	53.2	49.5	46.6	48.2	50.9	54.8	54.7	54.7	56.0	55.6	54.5
2014	C	55.5	52.8	49.0	48.9	50.1	53.4	55.0	55.7	56.8	57.0	57.9	59.7
2015	C	61.2	68.0	55.1	51.8	ND	56.0	55.2	56.7	59.0	59.0	58.5	57.8

Source: DWR 2016

Note:

WYT is Sacramento 40-30-30 Index

Key:
AN = Above Normal
BN = Below Normal
C = Critically Dry
D = Dry
W = Wet
WY = Water year
WYT = Water Year Type

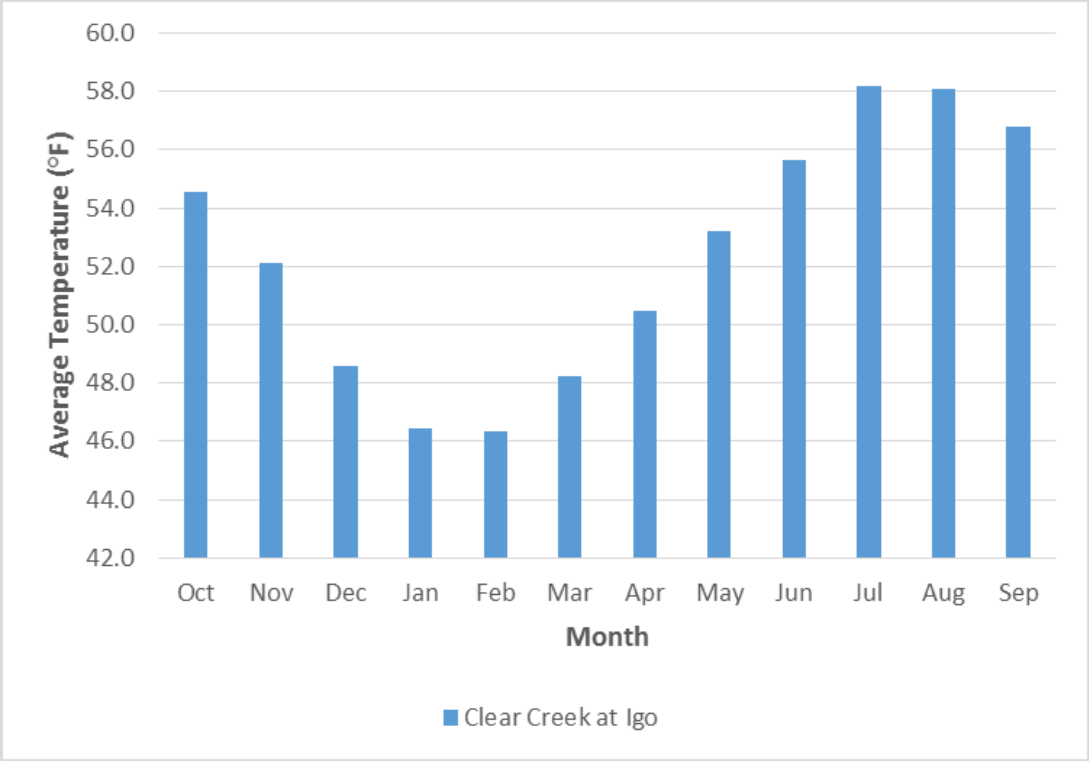


Figure 5-10. Monthly Average of Water Temperatures Recorded on Clear Creek at Igo (2001-2015)

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

Feather River from Lake Oroville to the Confluence with the Sacramento River Water quality constituents of concern in the lower Feather River have the potential to affect several supported beneficial uses, including municipal and agricultural water supply, contact and non-contact water recreation, and fish habitat and migration uses for cold and warm water.

Water Temperature The lower Feather River (downstream of Lake Oroville) is not listed on the 303(d) list as impaired by water temperature (SWRCB 2011a). However, water temperature in the lower Feather River is crucial to maintaining freshwater habitat for both warm and cold freshwater fish species in downstream habitats (DWR 2007). The SWP operates Lake Oroville and the Thermalito Reservoir Complex to meet temperature objectives—established through a 1983 agreement with California Department of Fish and Wildlife and BOs issued by NMFS. When necessary, Oroville will release water at different depths through shutters at the intake structures (DWR 2007). Temperature standards are in place for the low flow channel and the high flow channel. The low flow channel is the reach of the river between the Fish Barrier Dam and the confluence with the Thermalito Afterbay Outlet, and it is managed to protect cold water

fish species. The high flow channel is the downstream reach of the river, from the Thermalito Afterbay Outlet to the confluence with the Sacramento River.

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

Water Temperature The lower American River is not listed on the 303(d) list as impaired by water temperature (SWRCB 2011a). The lower American River supports warm and cold freshwater habitat beneficial uses, as well as migration and spawning uses. In particular, in-stream rearing of juvenile steelhead requires certain water temperatures which are targeted through water temperature objectives (CVRWQCB 2011, NMFS 2009). Temperature objectives on the American River are defined in NMFS BO Reasonable and Prudent Alternative II.2. The objective is to meet a daily average water temperature of 65°F or lower at Watt Avenue Bridge, from May 15 through October 31. If the 65°F temperature requirement cannot be met because of limited cold water availability in Folsom Reservoir, then on consultation with NMFS, the target daily average water temperature at Watt Avenue may be increased to as high as 68°F. The CVP operates Folsom Reservoir to meet the temperature objective by using the dam's selective withdrawal structure (shutters), which allows for release elevations to be adjusted based on temperature requirements.

Sacramento-San Joaquin River Delta

Water quality conditions in the Sacramento and San Joaquin Rivers in the Delta are described in this subsection against criteria to protect the beneficial uses as summarized in Table 5-1. The constituents of concern that are currently not in compliance with existing water quality standards, and for which TMDLs are adopted or are in development in this region.

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

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

The CVP and SWP are operated to achieve salinity objectives in the Delta under SWRCB D-1641. The requirements in SWRCB D-1641 define water quality objectives to protect agricultural, M&I, and fishery uses, and they vary throughout the year and sometimes by water year type. Objectives are specific to the western Delta, interior Delta, southern Delta and export area, as well as for inflows and outflows to the Delta from other water bodies. Compliance locations that will be analyzed here are Rock Slough and Banks Pumping Plants (M&I); Emmaton, Jersey Point, and C.W. Jones Pumping Plant (Jones Pumping Plant) (agriculture); and Collinsville (fish and wildlife).

The patterns of EC and salinity in the Delta, over time and space, follow predictable patterns—under the strong influence of higher saline water from the San Joaquin, and less saline water from the Sacramento and Eastside streams—in an ever-changing balance with tidal influence upstream from Suisun Bay, and the losses from south Delta pumping. The highest salinity occurs in the late summer months when the flows from the Sacramento and San Joaquin Rivers are the lowest, and sea water intrusion occurs. The lower Sacramento River at Collinsville experiences strong tidal influence during dry periods (EC above 8000 µmhos/cm), but is flushed with freshwater during winter flows.

For fish and wildlife protection, the SWRCB D-1641 also includes spring X2 criteria. The criteria require CVP and SWP operations to include upstream reservoir releases, from February through June, to maintain freshwater and estuarine conditions in the western Delta to protect aquatic life. In addition, the 2008 USFWS BO also includes an additional Delta salinity requirement in September and October in wet and above normal water years (Fall X2). X2 requirements are set in terms of maintaining X2 at, or westward of, three locations (Chipps Island, Roe Island and Collinsville). The number of days required at each location change, depending on the month and hydrologic condition.

Impact Analysis

Potential Mechanisms for Change and Analytical Methods

As described in Chapter 3, “Considerations for Describing Affected Environment and Environmental Consequences,” the impact analysis considers changes in surface water quality conditions related to changes in CVP and SWP operations under the alternatives, as compared to the No Action Alternative.

Changes in CVP and SWP operations (under the alternatives as compared to the No Action Alternative) could result in changes to surface water quality, due to changes in reservoir storage levels and river flows. Based on the discussion above, the following water quality changes are further analyzed in the *Evaluation of Alternatives* section.

As described in the section on *Affected Environment*, there are numerous constituents of concern that have been identified in the study area. These components are not all critical in each region, and they may not all be affected by changes in CVP and SWP operations considered in the EIS alternatives. The groups of constituents that could be affected by implementation of the alternatives have been identified through consideration of constituents of concern, described in the section on *Affected Environment*, and the anticipated implementation of TMDLs by 2030.

These constituents were grouped into major categories, as shown in Table 5-16. The constituents that already have approved TMDLs in certain regions are not further analyzed for those regions, as it is expected that the TMDL will be implemented by 2030. A complete list of TMDLs, and their anticipated completion dates.

Table 5-16. List of Surface Water Quality Constituents Considered for this Analysis

Constituent/Parameter Group	Individual Constituents/Parameters
Water Temperature	Water Temperature (Fahrenheit)
Salinity Indicators	Electrical Conductivity, Chloride, Delta X2
Nutrients (Klamath River Region Only)	Nitrate, Phosphorous
Dissolved Oxygen (Klamath River Region Only)	Dissolved Oxygen

Changes in Water Temperature

Changes in CVP and SWP operations would change water temperatures in rivers downstream of CVP and SWP reservoirs. Changes in water temperature are analyzed in comparison to the relevant temperature standards. Further analysis of the impacts of temperature changes on fisheries and aquatic habitat is presented Chapter 7, “Biological Resources – Fisheries.”

Temperature conditions on the Sacramento River, Clear Creek, and Trinity River at Lewiston were analyzed using the Trinity-Sacramento River HEC-5Q model. The HEC-5Q model simulates daily temperatures for the Trinity River (downstream of Lewiston Dam), Clear Creek (from Whiskeytown Dam to the Sacramento River confluence), and the Sacramento River (from Keswick Dam to the Feather River confluence). CalSim outputs were used to provide flow and storage inputs for HEC-5Q. Additional description of the HEC-5Q is provided in the Analytical Tools Technical Appendix.

Temperature conditions on the Trinity River (below Lewiston and on the lower Klamath River) were analyzed using the RBM10 model. RBM10 is a one-dimensional (laterally and depth averaged) water temperature model producing longitudinal temperature conditions in a river system (Yearsley et al. 2001, Yearsley 2009). RBM10 simulates daily temperatures and flows for locations along the Trinity River and Klamath Rivers. Upstream boundary conditions for RBM10 at Lewiston Dam are provided by HEC-5Q model outputs. Specific details of the Trinity River and Klamath River RBM10 models are provided in Jones et al. (2016) and Perry et al. (2011), respectively. For further description of RBM10 see the Analytical Tools Technical Appendix.

The analysis uses average water monthly temperatures to provide a comparison of the ability of the operations considered (under alternatives) to meet water temperature objectives. Monthly averages of temperatures do not allow a direct comparison to the temperature objectives, 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 would be exceeded, on a more or less frequent basis, in one alternative versus another.

In addition, for the Trinity and lower Klamath Rivers, the number of days when temperature objectives are exceeded is also analyzed. Daily results for the Sacramento River and Clear Creek are not analyzed because flows in HEC-5Q in the Sacramento Basin (based on CalSim II

outputs) are monthly averages only. While meteorological conditions are modeled in HEC-5Q on a sub-daily basis, the lack of daily flow patterning means that daily temperature model results will not be meaningful for assessing the frequency with which temperature objectives are met. Releases from Lewiston are patterned on a daily basis, so RBM10 results can be used to evaluate the number of days when temperature objectives are exceeded. The Analytical Tools Technical Appendix provides additional information on the RBM10 model, including the daily patterning of monthly CalSim II Lewiston releases prior to input into RBM10.

Changes in Salinity

Changes in salinity due to changes in CVP and SWP operations would be focused in the Delta. Salinity indicators generally considered in this analysis include EC, chloride, and X2.

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

Changes in Nutrients, Organic Matter, and Dissolved Oxygen

Analysis of changes in nutrients, organic matter, and DO—due to changes in CVP operations—is qualitative and focused in the Lower Klamath and Trinity River Region.

Evaluation of Alternatives

As described in Chapter 3, “Considerations for Describing Affected Environment and Environmental Consequences,” the action alternatives have been compared to the No Action Alternative.

No Action Alternative

Under the No Action Alternative, surface water quality would be comparable to the conditions described in the *Affected Environment* section of this chapter. Conditions in 2030 would be different than existing conditions—primarily due to climate change and sea-level rise, general plan development throughout California, and implementation of reasonable and foreseeable water resource management projects to provide water supplies. It is anticipated that climate change will result in a shift in winter precipitation from snow to rain, which will lead to larger runoff events in the winter and less snowmelt in the spring. Reservoir storage in turn will be reduced, because of the need to maintain flood space in the winter versus being able to store more predictable snowmelt-driven flows in the spring. Lower reservoir storages, combined with increases in ambient air temperatures, are expected to causes increases in water temperatures downstream of CVP and SWP reservoirs, compared to recent historical conditions. Sea-level rise is also likely to cause increased salinities in the Delta—and more eastward locations for X2—compared to recent historical conditions.

Proposed Action (Alternative 1)

Lower Klamath and Trinity River Region

Changes in Water Temperature

Trinity River: Lewiston Dam to the Klamath River Temperature impacts on the Trinity River (below Lewiston Dam) are evaluated by (1) comparing temperatures for the No Action Alternative with Alternative 1 at Trinity River below Lewiston Dam; Trinity River at Douglas City; Trinity River below North Fork Trinity River; Trinity River below South Fork Trinity

River; and Trinity River near mouth (Weitchpec); and (2) comparing the numbers of days (in the No Action Alternative and Alternative 1) that water temperatures exceeded water temperature objectives in the Trinity River identified in Table 5-3, above.

Temperatures below Lewiston Dam under Alternative 1 are similar to the No Action Alternative in most year types, and in most months, as shown in Table 5-17. In extremely wet, wet, and dry years, the monthly average water temperatures for Alternative 1 were within +/-0.5°F (less than 1 percent) of No Action conditions. In normal years, the maximum deviation is 1.3°F warmer (2 percent) in October, and for the remainder of the year changes in temperatures were less than +/-1.0°F (less than 2 percent). For the critically dry years, temperatures were up to 2.7°F (5 percent) warmer in July, and 1.0°F (-2 percent) and 1.7°F (-3 percent) cooler in August and September, respectively.

Table 5-17. Changes in Trinity River Temperature Below Lewiston Dam Under Alternative 1 as Compared to the No Action Alternative, by Trinity Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (°F)												
Extremely Wet	52.4	50.9	47.8	45.4	45.3	45.8	47.7	46.2	47.8	51.0	53.1	50.4
Wet	52.3	51.8	49.3	48.1	47.3	49.7	51.2	46.6	49.5	52.3	52.2	51.8
Normal	54.8	54.2	49.2	47.4	48.5	51.9	54.6	46.7	51.3	51.9	53.3	53.3
Dry	53.1	51.7	50.5	49.5	49.7	52.0	53.3	49.4	53.2	52.8	53.3	54.0
Critically Dry	55.0	50.2	50.4	51.1	51.9	51.3	52.9	52.0	54.9	54.9	57.5	57.5
Average All Years	53.0	51.7	49.5	48.2	48.2	50.0	51.7	47.8	50.9	52.4	53.2	52.9
Alternative 1 (°F)												
Extremely Wet	52.7	50.9	47.8	45.3	45.3	45.8	47.7	46.2	47.8	51.0	52.8	50.6
Wet	52.6	52.3	49.3	48.1	47.3	49.6	51.1	46.5	49.5	52.3	52.2	52.0
Normal	56.1	54.7	50.1	48.1	48.5	51.8	54.5	46.6	51.3	52.4	52.9	52.7
Dry	53.3	51.7	50.1	49.5	49.7	52.0	53.2	49.4	53.1	52.6	53.4	54.1
Critically Dry	55.1	50.2	50.7	51.2	52.0	51.7	52.9	52.1	54.9	57.6	56.5	55.8
Average All Years	53.3	51.9	49.5	48.3	48.2	50.0	51.6	47.8	50.9	52.7	53.1	52.8
No Action Compared to Alternative 1 (°F)												
Extremely Wet	0.3	0.1	0.0	0.0	0.0	-0.1	0.0	-0.1	0.0	0.0	-0.4	0.2
Wet	0.3	0.5	0.0	0.0	0.0	-0.1	-0.1	0.0	0.0	0.0	0.1	0.2
Normal	1.3	0.5	0.9	0.7	0.0	0.0	0.0	0.0	0.0	0.4	-0.4	-0.6
Dry	0.2	0.0	-0.4	0.0	0.0	0.0	0.0	0.0	0.0	-0.2	0.1	0.0
Critically Dry	0.2	0.1	0.3	0.2	0.1	0.4	0.0	0.0	0.0	2.7	-1.0	-1.7
Average All Years	0.3	0.2	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.2	-0.1	-0.1
No Action compared to Alternative 1 (%)												
Extremely Wet	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-1%	0%
Wet	1%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Normal	2%	1%	2%	1%	0%	0%	0%	0%	0%	1%	-1%	-1%
Dry	0%	0%	-1%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Critically Dry	0%	0%	1%	0%	0%	1%	0%	0%	0%	5%	-2%	-3%
Average All Years	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Key:
% = percent
ºF = degrees Fahrenheit

Temperatures at Douglas City under Alternative 1 are similar to under the No Action Alternative, in most year types and in most months, as shown in Table 5-18. In extremely wet, wet, and dry years, the monthly average water temperatures for Alternative 1 were within +/- 0.5°F (less than 1 percent) of No Action conditions. In normal years, the maximum deviation was 1.1°F warmer (2 percent) in October, and for the remainder of the year changes in temperature were less than +/-1.0°F (less than 2 percent). For the critically dry years temperatures were 2.4°F (4 percent) warmer in July, and 1.0°F (-2 percent) and 1.7°F (-3 percent) cooler in August and September, respectively.

Table 5-18. Changes in Trinity River Temperature at Douglas City Under Alternative 1 as Compared to the No Action Alternative, by Trinity Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (°F)												
Extremely Wet	52.2	49.3	46.0	43.2	44.3	44.9	46.8	47.1	48.6	52.5	54.8	51.4
Wet	52.1	50.2	47.0	45.1	45.3	47.8	49.5	47.2	50.3	53.5	53.5	52.3
Normal	54.4	51.5	45.9	43.9	45.3	47.1	52.7	47.1	52.0	52.9	54.1	53.7
Dry	52.8	50.2	47.8	46.4	46.4	48.8	51.9	49.8	54.1	54.2	54.1	54.2
Critically Dry	54.5	49.3	48.4	48.3	48.7	48.5	51.3	52.2	55.4	56.0	57.7	57.4
Average All Years	52.7	50.1	47.1	45.3	45.7	47.6	50.2	48.4	51.8	53.7	54.3	53.3
Alternative 1 (°F)												
Extremely Wet	52.4	49.3	45.9	43.2	44.3	44.9	46.8	47.1	48.6	52.5	54.5	51.6
Wet	52.4	50.6	47.0	45.1	45.2	47.8	49.5	47.1	50.3	53.6	53.5	52.5
Normal	55.5	51.7	46.3	44.1	45.3	47.1	52.7	47.1	51.9	53.3	53.6	52.9
Dry	52.9	50.2	47.5	46.5	46.5	48.8	51.9	49.8	54.1	54.0	54.1	54.1
Critically Dry	54.6	49.4	48.7	48.4	48.7	48.7	51.3	52.3	55.4	58.3	56.8	55.8
Average All Years	53.0	50.3	47.1	45.4	45.8	47.6	50.2	48.4	51.8	53.9	54.1	53.1
No Action Compared to Alternative 1 (°F)												
Extremely Wet	0.2	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	-0.3	0.2
Wet	0.2	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Normal	1.1	0.3	0.3	0.2	0.0	0.0	0.0	0.0	0.0	0.4	-0.5	-0.8
Dry	0.1	0.0	-0.3	0.0	0.0	0.0	0.0	0.0	0.0	-0.2	0.0	-0.1
Critically Dry	0.1	0.1	0.2	0.1	0.1	0.2	0.0	0.0	0.0	2.4	-1.0	-1.7
Average All Years	0.3	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	-0.2	-0.2
No Action compared to Alternative 1 (%)												
Extremely Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-1%	0%
Wet	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Normal	2%	1%	1%	0%	0%	0%	0%	0%	0%	1%	-1%	-2%
Dry	0%	0%	-1%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Critically Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	4%	-2%	-3%
Average All Years	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Key:
% = percent
ºF = degrees Fahrenheit

At the North Fork Trinity River, South Fork Trinity River and Weitchpec (Table 5-19 through Table 5-21, respectively), differences in temperature for all year types (for all months) were less than +/-1°F (1 percent) with the exception of normal, dry, and critically dry year types in August and September. Temperatures were consistently cooler than No Action conditions in these two months, by up to 6.6°F (-2 percent to -9 percent). Decreases in temperature in August and September were due to flow increases (associated with augmentation releases from Lewiston Dam that were drawn from cool, deep water releases from Trinity Reservoir), while minor increases or decreases in the other months of the year were due to changes in Trinity Lake operations, impacting storage in Trinity Lake storage or release rate and residence time in Lewiston Reservoir.

Table 5-19. Changes in Trinity River Temperature at North Fork Trinity River Under Alternative 1 as Compared to the No Action Alternative, by Trinity Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (°F)												
Extremely Wet	53.9	47.3	43.6	41.9	43.9	45.0	47.6	50.1	52.5	59.7	64.5	58.4
Wet	54.4	48.5	44.3	43.2	44.2	47.7	50.5	50.2	55.2	61.9	63.6	58.9
Normal	56.9	49.0	43.0	41.8	43.8	46.3	54.3	50.2	57.3	61.8	64.1	60.0
Dry	54.7	48.5	44.6	43.8	44.8	48.5	53.8	53.4	61.7	65.4	63.9	60.2
Critically Dry	56.0	47.7	44.3	45.0	46.8	48.0	53.1	55.9	62.4	67.2	66.8	63.5
Average All Years	54.8	48.3	44.2	43.2	44.5	47.4	51.6	51.6	57.5	63.0	64.2	59.7
Alternative 1 (°F)												
Extremely Wet	54.0	47.4	43.6	41.9	43.9	45.0	47.6	50.1	52.5	59.7	64.3	58.5
Wet	54.6	48.7	44.3	43.2	44.2	47.7	50.5	50.2	55.2	61.9	63.3	58.8
Normal	57.7	49.1	43.1	41.9	43.8	46.3	54.3	50.2	57.2	62.1	62.5	56.8
Dry	54.8	48.5	44.4	43.8	44.9	48.5	53.8	53.4	61.7	65.2	63.0	58.5
Critically Dry	56.1	47.7	44.5	45.1	46.8	48.1	53.1	55.9	62.4	68.9	64.6	59.5
Average All Years	55.0	48.4	44.1	43.2	44.5	47.4	51.6	51.6	57.5	63.2	63.4	58.6
No Action Compared to Alternative 1 (°F)												
Extremely Wet	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.2	0.1
Wet	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.2	-0.1
Normal	0.8	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.3	-1.6	-3.3
Dry	0.1	0.0	-0.2	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.9	-1.7
Critically Dry	0.1	0.1	0.1	0.1	0.0	0.1	0.0	0.0	0.0	1.7	-2.2	-4.0
Average All Years	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	-0.7	-1.2
No Action compared to Alternative 1 (%)												
Extremely Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Wet	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Normal	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-3%	-5%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-1%	-3%
Critically Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	2%	-3%	-6%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-1%	-2%

Key:
% = percent
ºF = degrees Fahrenheit

Table 5-20. Changes in Trinity River Temperature at South Fork Trinity River Under Alternative 1 as Compared to the No Action Alternative, by Trinity Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (°F)												
Extremely Wet	56.7	49.0	44.7	43.3	46.2	47.5	49.6	54.2	57.9	66.6	72.2	66.0
Wet	57.7	50.0	44.9	44.4	45.9	49.7	52.7	53.8	60.4	68.4	72.0	65.4
Normal	59.3	50.9	44.2	42.7	44.5	47.6	57.3	54.0	62.6	68.9	72.1	66.1
Dry	58.0	49.7	44.8	44.0	45.8	50.0	55.9	57.3	67.2	74.0	72.5	66.1
Critically Dry	58.8	47.8	42.9	44.3	46.9	48.8	54.5	58.8	66.5	75.2	74.1	69.1
Average All Years	57.9	49.6	44.6	43.9	45.9	49.1	53.7	55.4	62.8	70.4	72.4	66.1
Alternative 1 (°F)												
Extremely Wet	56.8	49.0	44.7	43.3	46.2	47.5	49.6	54.2	57.9	66.6	72.1	66.0
Wet	57.7	50.1	44.9	44.4	45.9	49.7	52.7	53.8	60.4	68.4	71.6	65.0
Normal	59.7	50.9	44.2	42.7	44.5	47.6	57.3	54.0	62.5	69.0	69.8	60.7
Dry	58.1	49.7	44.7	44.0	45.8	50.0	55.9	57.3	67.2	74.0	70.9	62.8
Critically Dry	58.8	47.8	43.0	44.3	46.9	48.9	54.5	58.8	66.5	76.0	71.2	62.7
Average All Years	57.9	49.6	44.6	43.9	45.9	49.1	53.7	55.4	62.8	70.5	71.3	63.9
No Action Compared to Alternative 1 (°F)												
Extremely Wet	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.0
Wet	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.4	-0.3
Normal	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	-2.3	-5.4
Dry	0.1	0.0	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-1.7	-3.3
Critically Dry	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.7	-3.0	-6.4
Average All Years	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	-1.1	-2.1
No Action compared to Alternative 1 (%)												
Extremely Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-1%	-1%
Normal	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-3%	-8%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-2%	-5%
Critically Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	-4%	-9%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-2%	-3%

Key:
% = percent
ºF = degrees Fahrenheit

Table 5-21. Changes in Trinity River Temperature at Mouth of Trinity River (Weitchpec) Under Alternative 1 as Compared to the No Action Alternative, by Trinity Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (°F)												
Extremely Wet	56.7	48.8	44.7	43.4	46.3	47.6	49.8	54.6	58.3	67.1	72.4	66.3
Wet	57.7	49.6	44.9	44.5	46.1	49.8	52.9	54.3	61.1	69.0	72.7	65.9
Normal	59.5	50.7	44.2	42.8	44.6	47.7	57.4	54.6	63.5	69.7	73.0	67.0
Dry	58.0	49.4	44.6	44.0	45.9	50.1	56.2	57.9	67.8	75.0	73.7	66.8
Critically Dry	58.6	47.7	42.6	44.1	47.0	49.0	54.9	59.5	67.3	76.2	75.2	69.9
Average All Years	57.9	49.3	44.5	44.0	46.0	49.3	53.9	55.9	63.4	71.2	73.2	66.7
Alternative 1 (°F)												
Extremely Wet	56.8	48.9	44.7	43.4	46.3	47.6	49.8	54.6	58.3	67.1	72.3	66.3
Wet	57.7	49.7	44.9	44.5	46.1	49.8	52.9	54.3	61.1	69.0	72.4	65.5
Normal	59.8	50.7	44.3	42.8	44.6	47.7	57.4	54.6	63.4	69.8	70.9	61.3
Dry	58.1	49.4	44.6	44.0	46.0	50.1	56.2	57.9	67.8	74.9	72.1	63.4
Critically Dry	58.7	47.7	42.7	44.2	47.0	49.0	54.9	59.5	67.3	76.8	72.4	63.3
Average All Years	57.9	49.4	44.5	44.0	46.0	49.3	53.9	55.9	63.4	71.2	72.2	64.4
No Action Compared to Alternative 1 (°F)												
Extremely Wet	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.0
Wet	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.4	-0.4
Normal	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	-2.1	-5.7
Dry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-1.6	-3.5
Critically Dry	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	-2.8	-6.6
Average All Years	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-1.0	-2.3
No Action compared to Alternative 1 (%)												
Extremely Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-1%	-1%
Normal	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-3%	-9%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-2%	-5%
Critically Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	-4%	-9%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-1%	-3%

Key:
% = percent
ºF = degrees Fahrenheit

Potential impacts on existing temperature objectives in the Trinity River (Table 5-) were assessed for the specific periods when objectives were applicable. A comparison of No Action versus Alternative 1 for the 1980 to 2003 RBM10 simulation period was completed to assess the frequency (number of days) of meeting temperature objectives based on daily average water temperature. In most years, temperature objectives were met throughout the designated temperature management period. However, there were periods objectives were not met, including:

- Increased frequency of meeting objectives under Alternative 1 compared to the No Action
- Decreased frequency of meeting objectives under Alternative 1 compared to the No Action than Alternative 1
- Equal frequency of meeting objectives for both No Action and Alternative 1.

The number of days that the objectives were not achieved is summarized in tabular form for the stipulated temperature objectives (i.e., temperature for each location and time period).

Noncompliance days for the Trinity River (at Douglas City between July 1 and September 30) are shown in Table 5-22. Temperature objectives at this location were largely met except in drier year types. Noncompliance for No Action and Alternative 1 occurred 40 and 46 days, respectively, between July 1 and September 15. Noncompliance for No Action and Alternative 1 occurred 27 and 31 days, respectively, between September 15 and September 30. The difference in non-compliance, between No Action and Alternative 1 at Douglas City, was 1 percent or less.

Noncompliance days for the Trinity River below North Fork Trinity River (between October 1 and December 31) are shown in Table 5-24. Temperature objectives at this location were not met as often as at Douglas City, being further downstream and influenced by atmospheric heating and tributary inputs. Noncompliance for No Action and Alternative 1 occurred 244 and 274 days, respectively, between October 1 and December 31. The difference in non-compliance, between No Action and Alternative 1 at North Fork Trinity River, was 1 percent.

The spring time objectives from the Record of Decision (ROD) for the Trinity River Trinity River Mainstem Fishery Restoration EIS/Environmental Impact Report (EIR) were also assessed (USFWS et al. 2000; DOI and Hoopa Valley Tribe 2000). These daily average water temperature objectives are applicable to the Trinity River, from Lewiston Dam to the confluence with the Klamath River. For this analysis, the number of non-compliance days for No Action and Alternative 1 were compared for all years in the RBM10 simulation period (1980-2003). Five locations were assessed: Trinity River below Lewiston Dam, Trinity River at Douglas City, Trinity River below North Fork Trinity River, Trinity River below South Fork Trinity River, and Trinity River near Weitchpec (Table 5-24 through Table 5-28, respectively). For the Trinity River (below Lewiston Dam and at Douglas City) there were few incidences of temperatures exceeding objectives—only a few days between April 15 and May 22. At the North Fork Trinity River the number of days increased slightly, but at the South Fork Trinity River and mouth locations, there was a high prevalence of non-compliance—with percentage of time exceeding objectives ranging from 18 percent to over 90 percent—with dry and critically dry years

experiencing the highest percentages in June. However, the difference between the No Action and Alternative 1 was less than 1 percent in all cases, indicating that these two alternatives were nearly identical in temperature response.

Table 5-22. Number of Days that No Action Alternative and Alternative 1 Temperatures at Douglas City Exceeded Basin Plan Temperature Objectives

Basin Plan Temperature Objective: Lewiston to Douglas City (RM 111 to RM 92)		**7/1 to 9/15 ≤ 60°F**		**9/15 to 9/30 ≤ 56°F**	
Year	**Trinity Water Year Type**	**No Action**	**Alt. 1**	**No Action**	**Alt. 1**
1980	W	0	0	0	0
1981	D	0	0	0	0
1982	EW	0	0	0	0
1983	EW	0	0	0	0
1984	W	0	0	0	0
1985	D	0	0	0	0
1986	W	0	0	0	0
1987	D	0	0	0	0
1988	D	0	0	0	0
1989	N	0	0	0	0
1990	D	0	0	7	**2**
1991	CD	33	**<u>37</u>**	15	15
1992	D	0	0	5	**<u>14</u>**
1993	W	1	**<u>2</u>**	0	0
1994	CD	0	0	0	0
1995	EW	6	6	0	0
1996	W	0	0	0	0
1997	W	0	0	0	0
1998	EW	0	0	0	0
1999	W	0	**<u>1</u>**	0	0
2000	W	0	0	0	0
2001	D	0	0	0	0
2002	N	0	0	0	0
2003	EW	0	0	0	0
# of Days of Non-compliance		40	46	27	31
Total # of Days		1,848	1,848	384	384
%		2%	2%	7%	8%

Note:
Bold values denote less days of non-compliance and **<u>bold underline</u>** days denote more days of non-compliance

Key:
% = percent
ºF = degrees Fahrenheit
CD = critically dry
D = dry
EW = extremely wet
N = normal
RM = River Mile
W = wet

Table 5-23. Number of Days that No Action Alternative and Alternative 1 Temperatures at Trinity River Below North Fork Trinity River Exceeded Basin Plan Temperature Objectives

Basin Plan Temperature Objective: Lewiston to North Fork Trinity River Confluence (RM 111 to RM 72)		**10/1 to 12/31 ≤ 56°F**	
Year	**Trinity Water Year Type**	**No Action**	**Alt. 1**
1980	W	10	10
1981	D	1	**<u>4</u>**
1982	EW	1	1
1983	EW	7	7
1984	W	1	1
1985	D	9	9
1986	W	2	2
1987	D	23	**<u>28</u>**
1988	D	22	**<u>24</u>**
1989	N	20	20
1990	D	11	11
1991	CD	22	22
1992	D	26	26
1993	W	10	**<u>14</u>**
1994	CD	14	**<u>18</u>**
1995	EW	0	0
1996	W	11	11
1997	W	1	1
1998	EW	1	1
1999	W	8	8
2000	W	9	9
2001	D	19	**<u>22</u>**
2002	N	6	**<u>15</u>**
2003	EW	10	10
# of Days of Non-compliance		244	274
Total # of Days		2,208	2,208
%		11%	12%

Note:
Bold values denote less days of non-compliance and **<u>bold underline</u>** days denote more days of non-compliance
Key:
% = percent
ºF = degrees Fahrenheit CD = critically dry
D = dry
EW = extremely wet
N = normal
RM = River Mile
W = wet

Table 5-24. Number of Days that No Action Alternative and Alternative 1 Average Daily Water Temperatures at Trinity River Below Lewiston Dam Exceeded Spring-Time Temperature Objectives

Spring-Time Temperature Objective: Lewiston to Weitchpec (RM 111 to RM 0.1)		**4/15 to 5/22** **≤ 55.4°F (for N, W & EW years)** **≤ 59.0°F (for D & CD years)**		**5/23 to 6/4** **≤ 59.0°F (for N, W & EW years)** **≤ 62.6°F (for D & CD years)**		**6/5 to 7/9** **≤ 62.6°F (for N, W & EW years)** **6/5 to 6/15** **≤ 68.0°F (for D & CD years)**	
Year	**Trinity Water Year Type**	**No Action**	**Alt. 1**	**No Action**	**Alt. 1**	**No Action**	**Alt. 1**
1980	W	6	6	0	0	0	0
1981	D	0	0	0	0	0	0
1982	EW	0	0	0	0	0	0
1983	EW	0	0	0	0	0	0
1984	W	0	0	0	0	0	0
1985	D	0	0	0	0	0	0
1986	W	0	0	0	0	0	0
1987	D	0	0	0	0	0	0
1988	D	0	0	0	0	0	0
1989	N	8	8	0	0	0	0
1990	D	0	0	0	0	0	0
1991	CD	0	0	0	0	0	0
1992	D	0	0	0	0	0	0
1993	W	0	0	0	0	0	0
1994	CD	0	0	0	0	0	0
1995	EW	0	0	0	0	0	0
1996	W	0	0	0	0	0	0
1997	W	0	0	0	0	0	0
1998	EW	0	0	0	0	0	0
1999	W	5	5	0	0	0	0
2000	W	0	0	0	0	0	0
2001	D	0	0	0	0	0	0
2002	N	0	0	0	0	0	0
2003	EW	0	0	0	0	0	0
# of days of Non-compliance		19	19	0	0	0	0
Total # of Days		888	888	360	360	840 (N/W/EW) 99 (D/CD)	840 (N/W/EW) 99 (D/CD)
%		2%	2%	0%	0%	0%/0%	0%/0%

Key:
% = percent
ºF = degrees Fahrenheit
CD = critically dry
D = dry
EW = extremely wet
N = normal
RM = River Mile
W = wet

Table 5-25. Number of Days that No Action Alternative and Alternative 1 Temperatures at Trinity River near Douglas City Exceeded Spring-Time Temperature Objectives

Spring-Time Temperature Objective: Lewiston to Weitchpec (RM 111 to RM 0.1)		**4/15 to 5/22** **≤ 55.4°F (for N, W & EW years)** **≤ 59.0°F (for D & CD years)**		**5/23 to 6/4** **≤ 59.0°F (for N, W & EW years)** **≤ 62.6°F (for D & CD years)**		**6/5 to 7/9** **≤ 62.6°F (for N, W & EW years)** **6/5 to 6/15** **≤ 68.0°F (for D & CD years)**	
Year	**Trinity Water Year Type**	**No Action**	**Alt. 1**	**No Action**	**Alt. 1**	**No Action**	**Alt. 1**
1980	W	0	0	0	0	0	0
1981	D	0	0	0	0	0	0
1982	EW	0	0	0	0	0	0
1983	EW	0	0	0	0	0	0
1984	W	0	0	0	0	0	0
1985	D	0	0	0	0	0	0
1986	W	0	0	0	0	0	0
1987	D	0	0	0	0	0	0
1988	D	0	0	0	0	0	0
1989	N	7	7	0	0	0	0
1990	D	0	0	0	0	0	0
1991	CD	0	0	0	0	0	0
1992	D	0	0	0	0	0	0
1993	W	0	0	0	0	0	0
1994	CD	0	0	0	0	0	0
1995	EW	0	0	0	0	0	0
1996	W	0	0	0	0	0	0
1997	W	0	0	0	0	0	0
1998	EW	0	0	0	0	0	0
1999	W	0	0	0	0	0	0
2000	W	0	0	0	0	0	0
2001	D	0	0	0	0	0	0
2002	N	0	0	0	0	0	0
2003	EW	0	0	0	0	0	0
# of days of Non-compliance		7	7	0	0	0	0
Total # of Days		888	888	360	360	840 (N/W/EW) 99 (D/CD)	840 (N/W/EW) 99 (D/CD)
%		1%	1%	0%	0%	0%/0%	0%/0%

Key:
% = percent
ºF = degrees Fahrenheit
CD = critically dry
D = dry
EW = extremely wet
N = normal
RM = River Mile
W = wet

Table 5-26. Number of Days that No Action Alternative and Alternative 1 Temperatures at Trinity River at the North Fork Trinity River Exceeded Spring-Time Temperature Objectives

Spring-Time Temperature Objective: Lewiston to Weitchpec (RM 111 to RM 0.1)		**4/15 to 5/22** **≤ 55.4°F (for N, W & EW years)** **≤ 59.0°F (for D & CD years)**		**5/23 to 6/4** **≤ 59.0°F (for N, W & EW years)** **≤ 62.6°F (for D & CD years)**		**6/5 to 7/9** **≤ 62.6°F (for N, W & EW years)** **6/5 to 6/15** **≤ 68.0°F (for D & CD years)**	
Year	**Trinity Water Year Type**	**No Action**	**Alt. 1**	**No Action**	**Alt. 1**	**No Action**	**Alt. 1**
1980	W	2	2	0	0	0	0
1981	D	0	0	0	0	1	1
1982	EW	0	0	0	0	0	0
1983	EW	1	1	0	0	0	0
1984	W	0	0	0	0	0	0
1985	D	0	0	0	0	0	0
1986	W	0	0	0	0	0	0
1987	D	1	1	0	0	0	0
1988	D	0	0	0	0	2	2
1989	N	7	7	0	0	0	0
1990	D	0	0	0	0	0	0
1991	CD	0	0	0	0	0	0
1992	D	0	0	1	1	3	3
1993	W	0	0	0	0	0	0
1994	CD	7	7	0	0	0	0
1995	EW	0	0	0	0	0	0
1996	W	0	0	0	0	0	0
1997	W	0	0	0	0	0	0
1998	EW	0	0	0	0	0	0
1999	W	3	3	0	0	0	0
2000	W	0	0	0	0	0	0
2001	D	3	3	0	0	0	0
2002	N	3	3	0	0	0	0
2003	EW	0	0	0	0	0	0
# of days of Non-compliance		27	27	1	1	0/6	0/6
Total # of Days		888	888	360	360	840 (N/W/EW) 99 (D/CD)	840 (N/W/EW) 99 (D/CD)
%		3%	3%	0%	0%	0%/6%	0%/6%

Key:
% = percent
ºF = degrees Fahrenheit
CD = critically dry
D = dry
EW = extremely wet
N = normal
RM = River Mile
W = wet

Table 5-27. Number of Days that No Action Alternative and Alternative 1 Temperatures at Trinity River Below South Fork Trinity River Exceeded Spring-Time Temperature Objectives

Spring-Time Temperature Objective: Lewiston to Weitchpec (RM 111 to RM 0.1)		**4/15 to 5/22** **≤ 55.4°F (for N, W & EW years)** **≤ 59.0°F (for D & CD years)**		**5/23 to 6/4** **≤ 59.0°F (for N, W & EW years)** **≤ 62.6°F (for D & CD years)**		**6/5 to 7/9** **≤ 62.6°F (for N, W & EW years)** **6/5 to 6/15** **≤ 68.0°F (for D & CD years)**	
Year	**Trinity Water Year Type**	**No Action**	**Alt. 1**	**No Action**	**Alt. 1**	**No Action**	**Alt. 1**
1980	W	24	24	0	0	0	0
1981	D	4	4	8	8	0	0
1982	EW	22	22	0	0	0	0
1983	EW	6	6	7	7	2	2
1984	W	3	3	0	0	21	21
1985	D	4	4	0	0	5	5
1986	W	6	6	3	3	14	14
1987	D	16	16	2	2	3	3
1988	D	2	2	0	0	0	0
1989	N	15	15	3	3	24	25
1990	D	9	9	0	0	0	0
1991	CD	0	0	0	1	3	3
1992	D	4	4	11	11	5	5
1993	W	7	7	0	0	23	23
1994	CD	16	16	11	11	2	2
1995	EW	4	4	0	0	14	14
1996	W	13	13	1	1	17	16
1997	W	23	23	0	0	9	9
1998	EW	18	18	0	0	4	4
1999	W	10	10	0	0	17	17
2000	W	6	6	0	0	19	19
2001	D	11	11	11	11	0	0
2002	N	10	10	6	6	18	18
2003	EW	0	0	0	0	5	4
# of days of Non-compliance		233	233	63	64	187/18	186/18
Total # of Days		888	888	360	360	840 (N/W/EW) 99 (D/CD)	840 (N/W/EW) 99 (D/CD)
%		26%	26%	18%	18%	22%/18%	22%/18%

Key:
% = percent
ºF = degrees Fahrenheit
CD = critically dry
D = dry
EW = extremely wet
N = normal
RM = River Mile
W = wet

Table 5-28. Number of Days that No Action Alternative and Alternative 1 Temperatures at Trinity River Near Weitchpec Exceeded Spring-Time Temperature Objectives

Spring-Time Temperature Objective: Lewiston to Weitchpec (RM 111 to RM 0.1)		**4/15 to 5/22 ≤ 55.4°F (for N, W & EW years) ≤ 59.0°F (for D & CD years)**		**5/23 to 6/4 ≤ 59.0°F (for N, W & EW years) ≤ 62.6°F (for D & CD years)**		**6/5 to 7/9 ≤ 62.6°F (for N, W & EW years) 6/5 to 6/15 ≤ 68.0°F (for D & CD years)**	
Year	**Trinity Water Year Type**	**No Action**	**Alt. 1**	**No Action**	**Alt. 1**	**No Action**	**Alt. 1**
1980	W	24	24	0	0	10	10
1981	D	4	4	8	8	0	0
1982	EW	23	23	0	0	1	1
1983	EW	7	7	8	7	3	3
1984	W	4	4	0	0	24	24
1985	D	4	4	0	0	5	5
1986	W	7	7	4	4	20	20
1987	D	18	18	3	3	4	4
1988	D	3	3	2	2	0	0
1989	N	19	19	3	3	30	32
1990	D	9	9	0	0	0	0
1991	CD	1	1	2	2	4	5
1992	D	10	10	12	12	7	7
1993	W	10	10	0	0	23	23
1994	CD	18	18	12	12	4	4
1995	EW	5	5	0	0	14	14
1996	W	14	14	1	1	20	20
1997	W	28	29	1	0	16	16
1998	EW	18	18	0	0	5	5
1999	W	10	10	2	2	20	20
2000	W	8	8	0	0	20	20
2001	D	13	13	13	13	0	0
2002	N	12	12	6	6	30	30
2003	EW	0	0	0	0	12	12
# of days of Non-compliance		269	270	77	75	248/24	250/25
Total # of Days		888	888	360	360	840 (N/W/EW) 99 (D/CD)	840 (N/W/EW) 99 (D/CD)
%		30%	30%	21%	21%	30%/24%	30%/25%

Key:
% = percent
ºF = degrees Fahrenheit
CD = critically dry
D = dry
EW = extremely wet
N = normal
RM = River Mile
W = wet

Klamath River: Below Trinity River The temperature impacts associated with Alternative 1 for Klamath River temperatures (near Klamath) were evaluated by comparing the simulated temperatures of the No Action Alternative and Alternative 1. A comparison of daily water temperature (averaged by month for Alternative 1 and No Action temperatures) is presented for each location, and tabular monthly averages are presented in Table 5-29. The alternatives identified herein do not increase the water temperature by 5°F (NCRWQCB 2011). Unlike the Trinity River, there are no site and location specific temperature objectives for the lower Klamath River.

Water temperatures at Klamath River (near Klamath) under Alternative 1 were similar to the No Action Alternative in most year types, and in most months, except August and September. In extremely wet and wet years, the monthly average water temperatures for Alternative 1 were within +/-0.5°F (less than 1 percent) of No Action conditions. For the normal, dry, and critically dry years, temperatures were 1.8°F (3 percent) to 4.0°F (6 percent) cooler. Temperatures in the Klamath River (at Klamath) did not exhibit the same magnitude of cooling, due to water comingling and heating from the confluence of the Trinity River through to the Klamath River Estuary.

Table 5-29. Changes in Klamath River near Klamath Water Temperature Under Alternative 1 as Compared to the No Action Alternative, by Trinity Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (°F)												
Extremely Wet	56.6	48.6	43.7	42.7	45.6	47.6	49.9	56.2	61.4	69.3	72.5	67.1
Wet	57.6	49.5	43.7	43.3	45.2	49.4	52.7	56.3	63.9	71.2	73.0	66.6
Normal	59.9	50.4	43.4	42.0	43.6	47.5	56.7	56.9	66.2	72.0	73.1	67.7
Dry	58.0	49.4	43.6	43.2	45.4	50.4	56.4	60.2	69.1	75.5	73.8	67.2
Critically Dry	58.5	48.6	42.2	43.1	46.7	49.8	55.5	60.6	68.3	76.9	74.4	69.7
Average All Years	57.8	49.3	43.5	43.0	45.3	49.3	53.9	57.9	65.6	72.7	73.3	67.2
Alternative 1 (°F)												
Extremely Wet	56.7	48.6	43.7	42.7	45.6	47.6	49.9	56.2	61.4	69.3	72.5	67.1
Wet	57.6	49.5	43.7	43.3	45.2	49.4	52.7	56.3	63.9	71.2	72.8	66.4
Normal	60.0	50.4	43.4	42.0	43.6	47.5	56.7	56.9	66.2	72.1	72.0	64.2
Dry	58.1	49.4	43.6	43.2	45.4	50.4	56.4	60.2	69.1	75.4	73.0	65.4
Critically Dry	58.5	48.6	42.2	43.1	46.7	49.9	55.5	60.6	68.3	77.2	72.8	65.7
Average All Years	57.9	49.3	43.5	43.0	45.3	49.3	53.9	57.9	65.6	72.8	72.7	66.0
No Action Compared to Alternative 1 (°F)												
Extremely Wet	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wet	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.2	-0.2
Normal	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	-1.1	-3.5
Dry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.8	-1.8
Critically Dry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	-1.5	-4.0
Average All Years	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.5	-1.3
No Action compared to Alternative 1 (%)												
Extremely Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-2%	-5%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-1%	-3%
Critically Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-2%	-6%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-1%	-2%

Key:
% = percent
ºF = degrees Fahrenheit

Changes in Nutrients, Organic Matter, and Dissolved Oxygen

Trinity River: Lewiston Dam to Klamath River For the Trinity River under Alternative 1, nutrient concentrations, organic matter and DO would be similar to the No Action Alternative because all releases from Trinity Reservoir would be of similar quality.

Klamath River: Below Trinity River For the lower Klamath River, under Alternative 1, lower nutrient and organic matter concentrations would be anticipated during August and September in comparison to the No Action Alternative. The Trinity River typically experiences lower nutrient and organic matter conditions than the Klamath River. Thus, during periods when augmentation flows occur, contributions from the Trinity River will result in lower nutrient and organic matter concentrations in the Klamath River below the Trinity River confluence due to dilution effects. Concentration of blue-green algae is expected to be similar or lower in comparison to the No Action Alternative because high temperature and nutrient conditions that contribute to algal blooms would not increase in frequency or magnitude.

For the lower Klamath River, under Alternative 1, similar DO concentrations would be anticipated during August and September in comparison to the No Action Alternative. This is because mechanical reaeration maintains DO at or near saturation concentration. Because DO saturation concentration is a function of water temperature, the lower Klamath River may experience slightly lower DO concentrations during augmentation due to slightly cooler water temperatures.

Central Valley and Bay-Delta Region

Changes in Water Temperature

Sacramento River Below Keswick Dam Water temperatures on the Sacramento River are summarized in Table 5-30 through Table 5-33. Water temperatures on the Sacramento River below Clear Creek, and at Balls Ferry, Jellys Ferry, and Bend Bridge (under Alternative 1),would be similar to the No Action Alternative with all months—of all year types—changing less than, or equal to, 1 percent.

Table 5-30. Changes in Water Temperature on Sacramento River Below Clear Creek Under Alternative 1 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (°F)												
Wet	55.1	54.8	50.7	47.0	45.9	46.6	48.5	50.1	51.0	51.9	53.2	52.0
Above Normal	55.9	54.8	50.8	47.4	46.2	47.4	49.0	50.5	50.7	51.3	52.8	52.6
Below Normal	55.1	55.0	51.5	48.1	47.3	48.9	49.9	50.8	51.3	52.3	53.6	54.9
Dry	55.8	55.0	51.2	48.3	47.8	49.0	50.3	51.1	51.5	52.9	54.9	55.9
Critical	58.4	56.1	51.7	47.9	47.6	49.4	50.3	52.6	54.1	56.0	59.1	62.3
Average All Years	55.9	55.1	51.1	47.7	46.9	48.1	49.5	50.9	51.6	52.7	54.5	55.0
Alternative 1 (°F)												
Wet	55.1	54.8	50.7	47.0	45.9	46.6	48.5	50.1	51.0	51.9	53.2	52.0
Above Normal	55.9	54.9	50.9	47.4	46.2	47.4	49.0	50.5	50.7	51.3	52.8	52.6
Below Normal	55.0	55.0	51.5	48.1	47.3	48.9	49.9	50.8	51.3	52.3	53.6	54.9
Dry	55.7	55.0	51.2	48.3	47.8	49.0	50.3	51.1	51.5	52.9	54.9	55.8
Critical	58.5	56.1	51.7	47.8	47.6	49.4	50.3	52.7	54.2	56.0	59.0	62.9
Average All Years	55.9	55.1	51.1	47.7	46.9	48.1	49.5	50.9	51.6	52.7	54.5	55.1
No Action Compared to Alternative 1 (°F)												
Wet	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Above Normal	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Below Normal	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dry	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1
Critical	0.1	0.0	0.0	-0.1	0.0	0.0	0.0	0.1	0.1	0.0	-0.1	0.6
Average All Years	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
No Action Compared to Alternative 1 (%)												
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Below Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Critical	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Key:
% = percent
ºF = degrees Fahrenheit

Table 5-31. Changes in Water Temperature on Sacramento River at Balls Ferry Under Alternative 1 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (°F)												
Wet	55.6	54.3	49.7	46.7	46.2	47.3	50.1	52.4	53.0	53.3	54.5	52.8
Above Normal	56.4	54.4	50.0	47.0	46.4	48.2	50.7	52.5	52.3	52.4	54.0	53.6
Below Normal	55.5	54.5	50.6	47.5	47.5	49.7	51.4	52.5	52.8	53.4	54.7	56.2
Dry	56.2	54.6	50.4	47.8	47.9	49.8	51.9	53.0	52.9	54.1	56.1	57.3
Critical	58.8	55.9	51.0	47.6	48.0	50.4	51.5	54.2	55.5	57.1	60.2	63.3
Average All Years	56.3	54.7	50.2	47.3	47.1	48.8	51.0	52.8	53.2	54.0	55.7	56.1
Alternative 1 (°F)												
Wet	55.6	54.3	49.7	46.7	46.2	47.3	50.0	52.4	53.0	53.3	54.5	52.8
Above Normal	56.4	54.5	50.0	47.0	46.4	48.2	50.6	52.5	52.3	52.4	54.0	53.6
Below Normal	55.5	54.5	50.6	47.5	47.5	49.7	51.4	52.5	52.8	53.5	54.7	56.2
Dry	56.2	54.6	50.4	47.8	47.9	49.8	51.9	53.0	52.9	54.1	56.1	57.2
Critical	58.9	55.9	51.0	47.6	48.0	50.4	51.5	54.2	55.5	57.1	60.1	63.8
Average All Years	56.3	54.7	50.2	47.2	47.1	48.8	51.0	52.8	53.2	54.0	55.7	56.1
No Action Compared to Alternative 1 (°F)												
Wet	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	0.0	0.0	0.0
Above Normal	0.0	0.1	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	0.0	0.0	0.0
Below Normal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
Dry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1
Critical	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.5
Average All Years	0.0	0.0	0.0	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
No Action Compared to Alternative 1 (%)												
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Below Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Critical	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Key:
% = percent
ºF = degrees Fahrenheit

Table 5-32. Changes in Water Temperature on Sacramento River at Jellys Ferry Under Alternative 1 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (°F)												
Wet	56.0	53.8	48.9	46.4	46.4	48.1	51.6	54.7	55.4	55.1	56.1	53.8
Above Normal	56.9	54.0	49.2	46.6	46.6	49.0	52.2	54.9	54.3	53.8	55.4	54.8
Below Normal	56.0	54.0	49.6	46.9	47.6	50.4	53.0	54.4	54.5	54.8	56.0	57.7
Dry	56.6	54.2	49.6	47.3	47.9	50.4	53.4	55.0	54.5	55.4	57.5	58.9
Critical	59.0	55.5	50.2	47.2	48.3	51.2	52.8	55.9	57.0	58.4	61.3	64.2
Average All Years	56.7	54.2	49.4	46.8	47.2	49.6	52.5	54.9	55.1	55.4	57.1	57.3
Alternative 1 (°F)												
Wet	56.1	53.9	48.9	46.4	46.4	48.1	51.6	54.7	55.4	55.1	56.1	53.8
Above Normal	56.8	54.1	49.2	46.6	46.6	49.0	52.2	54.9	54.3	53.9	55.4	54.8
Below Normal	55.9	54.0	49.6	46.9	47.6	50.4	53.0	54.4	54.5	54.8	56.0	57.7
Dry	56.6	54.2	49.6	47.3	47.9	50.4	53.4	55.0	54.5	55.4	57.5	58.8
Critical	59.2	55.5	50.2	47.2	48.3	51.2	52.8	56.0	57.1	58.4	61.3	64.7
Average All Years	56.8	54.2	49.4	46.8	47.2	49.6	52.5	54.9	55.1	55.4	57.1	57.4
No Action Compared to Alternative 1 (°F)												
Wet	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Above Normal	-0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
Below Normal	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1
Critical	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.5
Average All Years	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
No Action Compared to Alternative 1 (%)												
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Below Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Critical	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Key:
% = percent
ºF = degrees Fahrenheit

Table 5-33. Changes in Water Temperature on Sacramento River at Bend Bridge Under Alternative 1 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (°F)												
Wet	56.3	53.5	48.5	46.4	46.6	48.6	52.3	55.6	56.4	56.2	57.3	54.6
Above Normal	57.2	53.7	48.8	46.5	46.8	49.7	53.2	55.9	55.4	54.9	56.6	55.7
Below Normal	56.2	53.7	49.1	46.7	47.7	51.0	53.7	55.4	55.6	55.8	57.1	58.8
Dry	56.9	53.8	49.1	47.0	47.9	51.0	54.2	56.1	55.7	56.6	58.7	60.0
Critical	59.3	55.2	49.7	47.0	48.5	51.7	53.6	56.9	58.1	59.5	62.2	64.8
Average All Years	57.0	53.9	49.0	46.7	47.4	50.1	53.3	55.9	56.2	56.5	58.2	58.2
Alternative 1 (°F)												
Wet	56.3	53.5	48.5	46.4	46.6	48.6	52.3	55.6	56.4	56.2	57.3	54.6
Above Normal	57.1	53.8	48.8	46.5	46.8	49.6	53.2	55.9	55.4	54.9	56.6	55.7
Below Normal	56.2	53.7	49.1	46.7	47.7	51.0	53.7	55.4	55.6	55.9	57.1	58.8
Dry	56.9	53.8	49.2	47.0	47.9	51.0	54.2	56.1	55.7	56.6	58.8	60.0
Critical	59.4	55.2	49.7	47.0	48.4	51.7	53.6	56.9	58.1	59.5	62.2	65.2
Average All Years	57.0	53.9	49.0	46.7	47.4	50.1	53.3	55.9	56.2	56.5	58.2	58.2
No Action Compared to Alternative 1 (°F)												
Wet	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Above Normal	-0.1	0.1	0.0	0.0	0.0	-0.1	0.0	0.0	0.0	0.0	0.0	0.0
Below Normal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
Dry	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
Critical	0.1	0.0	0.0	0.0	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.4
Average All Years	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
No Action Compared to Alternative 1 (%)												
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Below Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Critical	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Key:
% = percent
ºF = degrees Fahrenheit

Clear Creek below Whiskeytown Dam Water temperatures on Clear Creek at Igo are summarized in Table 5-34. Water temperatures on Clear Creek (under Alternative 1) would be similar to the No Action Alternative with all months—of all year types—changing less than, or equal to, 1 percent.

Table 5-34. Changes in Water Temperature on Clear Creek at Igo Under Alternative 1 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (°F)												
Wet	52.2	50.4	46.6	44.5	44.5	45.5	47.2	48.7	50.8	54.8	55.0	52.7
Above Normal	53.4	50.9	46.7	44.7	44.6	45.6	47.3	48.7	50.9	54.8	54.8	52.9
Below Normal	52.4	50.3	46.6	44.3	44.7	46.2	47.9	48.8	51.2	55.1	55.3	53.9
Dry	53.5	50.9	47.1	45.0	45.1	46.4	48.0	49.0	51.4	55.3	56.0	54.5
Critical	55.7	52.9	48.3	45.9	46.1	47.3	49.1	50.8	54.4	56.3	56.9	57.6
Average All Years	53.3	51.0	47.0	44.8	44.9	46.1	47.8	49.1	51.5	55.2	55.5	54.1
Alternative 1 (°F)												
Wet	52.2	50.4	46.6	44.5	44.5	45.5	47.2	48.7	50.8	54.7	55.0	52.7
Above Normal	53.5	51.0	46.8	44.7	44.6	45.6	47.3	48.7	50.9	54.8	54.9	52.9
Below Normal	52.4	50.3	46.6	44.3	44.7	46.2	47.9	48.8	51.1	55.1	55.3	53.9
Dry	53.5	51.0	47.1	45.0	45.1	46.4	48.0	49.0	51.4	55.3	56.0	54.4
Critical	55.7	53.0	48.4	46.0	46.1	47.3	49.1	50.8	54.4	56.2	56.8	57.3
Average All Years	53.3	51.0	47.0	44.8	45.0	46.1	47.8	49.1	51.6	55.1	55.5	54.0
No Action Compared to Alternative 1 (°F)												
Wet	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0
Above Normal	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
Below Normal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	0.0
Dry	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1
Critical	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.3
Average All Years	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1	-0.1	0.0	-0.1
No Action Compared to Alternative 1 (%)												
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Below Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Critical	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-1%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Key:
% = percent
ºF = degrees Fahrenheit

Feather River Below Thermalito/Oroville Dam Temperatures on the Feather River were not modelled, but because Oroville storage and releases change by 1 percent or less (in Alternative 1 as compared to the No Action Alternative), changes in downstream water temperatures are assumed to be similar. See Tables 4-11 and 4-13 in Chapter 4, "Surface Water Supply and Management," for changes in Oroville storage and flows on the Feather River.

American River Below Nimbus Dam Temperatures on the American River were not modelled, but because Folsom storage and releases change by 1 percent or less (in Alternative 1

as compared to the No Action Alternative), changes in downstream water temperatures are assumed to be similar. See Tables 4-15 and 4-17 in Chapter 4, "Surface Water Supply and Management," for changes in Folsom storage and flows on the American River.

Changes in Salinity

Delta Salinity Salinities in the Delta at Rock Slough, Emmaton, Jersey Point, Collinsville, and at Banks and Jones Pumping Plants are summarized in Table 5-35 through Table 5-40. Salinities at these six locations under Alternative 1 would be similar to the No Action Alternative—with all months, of all year types, changing less than, or equal to, 1 percent.

Table 5-35. Changes in Salinity (EC) at Rock Slough Under Alternative 1 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (umhos/cm)												
Wet	569	538	520	586	588	533	455	392	280	278	338	575
Above Normal	783	870	741	596	543	524	402	416	289	282	362	563
Below Normal	579	551	565	663	529	427	409	419	307	346	467	696
Dry	695	727	748	756	510	426	384	378	306	414	647	735
Critical	909	997	1,043	977	627	487	418	417	423	539	749	887
Average All Years	685	706	693	696	560	484	417	400	312	359	495	674
Alternative 1 (umhos/cm)												
Wet	568	539	520	586	588	533	455	392	280	278	338	575
Above Normal	782	872	738	595	543	523	402	416	289	282	362	562
Below Normal	580	552	565	664	530	427	409	418	307	345	466	695
Dry	696	727	747	756	510	425	384	378	306	412	644	732
Critical	912	1,003	1,049	981	627	487	418	417	422	538	747	890
Average All Years	685	707	694	697	560	484	417	400	312	359	493	674
No Action Compared to Alternative 1 (umhos/cm)												
Wet	-1	1	0	0	0	0	0	0	0	0	0	0
Above Normal	-1	2	-3	-1	0	-1	0	0	0	0	0	-1
Below Normal	1	1	0	1	1	0	0	-1	0	-1	-1	-1
Dry	1	0	-1	0	0	-1	0	0	0	-2	-3	-3
Critical	3	6	6	4	0	0	0	0	-1	-1	-2	3
Average All Years	0	1	1	1	0	0	0	0	0	0	-2	0
No Action Compared to Alternative 1 (%)												
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Below Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-1%	0%
Critical	0%	1%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Key:
% = percent
EC = electrical conductivity
umhos/cm = micromhos per centimeter

Table 5-36. Changes in Salinity (EC) on Sacramento River at Emmaton Under Alternative 1 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (umhos/cm)												
Wet	1,323	774	312	214	184	183	187	192	276	297	838	328
Above Normal	2,713	1,735	720	271	193	184	193	209	384	347	855	557
Below Normal	1,386	1,079	869	463	248	223	244	292	551	501	1,113	2,228
Dry	2,242	1,822	1,298	599	286	222	248	327	607	986	2,119	2,866
Critical	3,430	3,346	2,163	1,017	437	358	436	815	1,503	2,134	3,007	3,860
Average All Years	2,084	1,599	963	468	256	224	247	332	591	769	1,508	1,755
Alternative 1 (umhos/cm)												
Wet	1,324	775	312	214	184	183	187	192	276	297	838	328
Above Normal	2,719	1,720	720	271	193	184	192	209	384	347	856	558
Below Normal	1,386	1,077	869	463	248	223	244	292	551	503	1,118	2,233
Dry	2,243	1,819	1,295	598	285	222	248	327	607	991	2,127	2,861
Critical	3,445	3,357	2,168	1,016	436	358	436	815	1,498	2,146	3,031	3,886
Average All Years	2,088	1,598	963	467	256	224	247	332	590	773	1,514	1,758
No Action Compared to Alternative 1 (umhos/cm)												
Wet	1	1	0	0	0	0	0	0	0	0	0	0
Above Normal	6	-15	0	0	0	0	-1	0	0	0	1	1
Below Normal	0	-2	0	0	0	0	0	0	0	2	5	5
Dry	1	-3	-3	-1	-1	0	0	0	0	5	8	-5
Critical	15	11	5	-1	-1	0	0	0	-5	12	24	26
Average All Years	4	-1	0	-1	0	0	0	0	-1	4	6	3
No Action Compared to Alternative 1 (%)												
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	0%	-1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Below Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Critical	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	1%	1%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Key:
% = percent
EC = electrical conductivity
umhos/cm = micromhos per centimeter

Table 5-37. Changes in Salinity (EC) on San Joaquin River at Jersey Point Under Alternative 1 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (umhos/cm)												
Wet	1,114	958	503	284	238	221	222	214	239	345	1,063	936
Above Normal	2,148	1,759	1,088	465	252	218	229	239	305	468	1,178	1,007
Below Normal	1,107	1,151	1,168	692	325	243	248	276	378	816	1,458	2,431
Dry	1,693	1,689	1,590	952	389	255	248	288	416	1,298	1,704	2,466
Critical	2,459	2,509	2,134	1,309	536	330	352	542	904	1,613	2,115	2,718
Average All Years	1,615	1,516	1,189	680	332	248	252	292	409	846	1,445	1,782
Alternative 1 (umhos/cm)												
Wet	1,116	959	503	284	238	221	222	214	239	345	1,063	936
Above Normal	2,149	1,741	1,086	465	252	218	229	239	305	468	1,177	1,007
Below Normal	1,107	1,151	1,169	692	326	243	248	276	378	815	1,455	2,431
Dry	1,693	1,685	1,590	951	388	255	248	288	416	1,290	1,692	2,461
Critical	2,468	2,521	2,142	1,309	535	330	352	542	906	1,606	2,116	2,726
Average All Years	1,617	1,514	1,190	680	332	248	252	292	409	842	1,441	1,781
No Action Compared to Alternative 1 (umhos/cm)												
Wet	2	1	0	0	0	0	0	0	0	0	0	0
Above Normal	1	-18	-2	0	0	0	0	0	0	0	-1	0
Below Normal	0	0	1	0	1	0	0	0	0	-1	-3	0
Dry	0	-4	0	-1	-1	0	0	0	0	-8	-12	-5
Critical	9	12	8	0	-1	0	0	0	2	-7	1	8
Average All Years	2	-2	1	0	0	0	0	0	0	-4	-4	-1
No Action Compared to Alternative 1 (%)												
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	0%	-1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Below Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	-1%	-1%	0%
Critical	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Key:
% = percent
EC = electrical conductivity
umhos/cm = micromhos per centimeter

Table 5-38. Changes in Salinity (EC) on Sacramento River at Collinsville Under Alternative 1 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (umhos/cm)												
Wet	4,127	2,900	1,039	403	200	198	218	291	916	1,422	3,821	1,226
Above Normal	7,539	5,358	2,987	778	261	220	249	421	1,716	1,869	3,925	2,880
Below Normal	4,255	3,826	3,579	2,046	752	599	725	1,154	2,518	2,746	4,747	7,305
Dry	6,541	6,049	5,129	2,772	956	540	778	1,409	2,765	4,487	6,762	8,422
Critical	9,144	9,192	7,249	4,254	1,845	1,454	2,011	3,327	5,037	6,844	8,416	9,739
Average All Years	6,008	5,103	3,595	1,824	709	523	690	1,145	2,312	3,212	5,351	5,305
Alternative 1 (umhos/cm)												
Wet	4,130	2,900	1,040	403	200	198	218	291	916	1,423	3,821	1,226
Above Normal	7,542	5,316	2,987	778	261	220	249	421	1,715	1,869	3,926	2,882
Below Normal	4,256	3,825	3,579	2,047	752	599	725	1,154	2,518	2,756	4,758	7,315
Dry	6,543	6,044	5,121	2,766	952	540	778	1,409	2,765	4,496	6,766	8,415
Critical	9,162	9,206	7,257	4,251	1,842	1,454	2,010	3,328	5,032	6,855	8,446	9,767
Average All Years	6,013	5,097	3,594	1,822	707	523	690	1,145	2,311	3,217	5,359	5,309
No Action Compared to Alternative 1 (umhos/cm)												
Wet	3	0	1	0	0	0	0	0	0	1	0	0
Above Normal	3	-42	0	0	0	0	0	0	-1	0	1	2
Below Normal	1	-1	0	1	0	0	0	0	0	10	11	10
Dry	2	-5	-8	-6	-4	0	0	0	0	9	4	-7
Critical	18	14	8	-3	-3	0	-1	1	-5	11	30	28
Average All Years	5	-6	-1	-2	-2	0	0	0	-1	5	8	4
No Action Compared to Alternative 1 (%)												
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	0%	-1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Below Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Critical	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Key:
% = percent
EC = electrical conductivity
umhos/cm = micromhos per centimeter

Table 5-39. Changes in Salinity (EC) at Banks Pumping Plant Under Alternative 1 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (umhos/cm)												
Wet	473	443	428	470	389	329	250	276	301	281	307	458
Above Normal	667	662	571	591	517	407	331	362	324	274	317	414
Below Normal	478	460	494	584	558	476	380	424	356	306	392	615
Dry	570	588	600	663	592	549	452	453	352	364	515	632
Critical	742	780	788	768	708	690	569	535	452	490	605	740
Average All Years	568	565	554	595	528	467	376	391	347	334	414	556
Alternative 1 (umhos/cm)												
Wet	473	443	428	470	389	329	250	276	301	281	307	458
Above Normal	668	661	570	592	517	407	331	362	324	274	317	414
Below Normal	479	460	495	584	558	476	380	424	356	306	391	615
Dry	571	588	599	664	592	549	452	453	352	363	511	631
Critical	745	785	792	769	709	690	569	535	450	489	603	741
Average All Years	568	565	554	596	528	467	376	391	346	334	413	556
No Action Compared to Alternative 1 (umhos/cm)												
Wet	0	0	0	0	0	0	0	0	0	0	0	0
Above Normal	1	-1	-1	1	0	0	0	0	0	0	0	0
Below Normal	1	0	1	0	0	0	0	0	0	0	-1	0
Dry	1	0	-1	1	0	0	0	0	0	-1	-4	-1
Critical	3	5	4	1	1	0	0	0	-2	-1	-2	1
Average All Years	0	0	0	1	0	0	0	0	-1	0	-1	0
No Action Compared to Alternative 1 (%)												
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Below Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-1%	0%
Critical	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Key:
% = percent
EC = electrical conductivity
umhos/cm = micromhos per centimeter

Table 5-40. Changes in Salinity (EC) at Jones Pumping Plant Under Alternative 1 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (umhos/cm)												
Wet	473	455	496	517	406	336	265	288	345	345	331	449
Above Normal	624	627	608	631	572	449	353	375	373	332	343	426
Below Normal	478	469	564	627	618	531	405	433	392	334	407	581
Dry	550	570	633	687	664	619	483	480	388	383	512	602
Critical	684	721	761	774	784	787	621	569	472	492	588	696
Average All Years	547	551	595	629	579	515	403	409	385	372	425	536
Alternative 1 (umhos/cm)												
Wet	473	455	496	517	406	336	265	288	345	345	331	449
Above Normal	624	627	608	631	572	449	353	375	373	332	343	426
Below Normal	479	469	564	627	619	531	405	433	392	335	407	580
Dry	550	570	632	688	664	619	483	480	388	383	510	600
Critical	686	725	764	773	783	787	621	569	470	491	586	697
Average All Years	548	552	595	629	579	515	403	409	385	372	424	536
No Action Compared to Alternative 1 (umhos/cm)												
Wet	0	0	0	0	0	0	0	0	0	0	0	0
Above Normal	0	0	0	0	0	0	0	0	0	0	0	0
Below Normal	1	0	0	0	1	0	0	0	0	1	0	-1
Dry	0	0	-1	1	0	0	0	0	0	0	-2	-2
Critical	2	4	3	-1	-1	0	0	0	-2	-1	-2	1
Average All Years	1	1	0	0	0	0	0	0	0	0	-1	0
No Action Compared to Alternative 1 (%)												
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Below Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Critical	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Key:
% = percent
EC = electrical conductivity
umhos/cm = micromhos per centimeter

X2 Position X2 positions are summarized in Table 5-41. X2 positions in Alternative 1 would be similar to the No Action Alternative—with all months, of all year types, changing less than, or equal to, 1 percent.

Table 5-41. Changes in X2 Position Under Alternative 1 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (km)												
Wet	80.6	76.8	63.7	54.8	51.2	53.1	55.1	58.4	67.3	74.9	82.8	73.9
Above Normal	86.8	82.6	75.2	60.9	54.9	55.3	59.1	65.2	75.3	77.8	83.1	74.7
Below Normal	80.4	80.3	80.4	74.6	64.3	66.9	69.0	72.9	79.1	81.1	85.1	89.4
Dry	85.7	85.5	84.5	77.7	67.7	65.4	68.8	74.5	80.1	84.5	87.6	90.6
Critical	90.5	90.7	88.3	82.1	75.3	74.6	77.7	82.3	85.2	87.9	90.3	92.2
Average All Years	84.2	82.4	76.4	68.0	61.1	61.4	64.2	68.9	75.9	80.4	85.4	82.9
Alternative 1 (km)												
Wet	80.6	76.8	63.7	54.8	51.2	53.1	55.1	58.4	67.3	74.9	82.8	73.9
Above Normal	86.8	82.6	75.2	60.9	54.9	55.3	59.1	65.2	75.3	77.8	83.1	74.7
Below Normal	80.4	80.3	80.4	74.6	64.3	66.9	69.1	72.9	79.1	81.1	85.1	89.4
Dry	85.7	85.5	84.5	77.7	67.7	65.4	68.8	74.5	80.1	84.5	87.6	90.5
Critical	90.5	90.7	88.3	82.1	75.3	74.6	77.7	82.3	85.2	87.9	90.3	92.2
Average All Years	84.2	82.4	76.4	68.0	61.1	61.4	64.2	68.9	75.9	80.4	85.4	82.9
No Action Compared to Alternative 1 (km)												
Wet	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Above Normal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Below Normal	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Dry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1
Critical	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Average All Years	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
No Action Compared to Alternative 1 (%)												
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Below Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Critical	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Key:
% = percent
km = kilometer

Trinity River Record of Decision Flow Rescheduling Alternative (Alternative 2)

Lower Klamath and Trinity River Region

Changes in Water Temperature

Trinity River: Lewiston Dam to Klamath River Temperature impacts on the Trinity River (below Lewiston Dam) are evaluated by (1) comparing temperatures for the No Action Alternative with Alternative 2 at Trinity River below Lewiston Dam; Trinity River at Douglas City; Trinity River below North Fork Trinity River; Trinity River below South Fork Trinity River; and Trinity River near its mouth (Weitchpec); and (2) comparing the numbers of days (in the No Action Alternative and Alternative 2) that water temperatures exceeded water temperature objectives in the Trinity River, as identified in Table 5-3.

Temperatures below Lewiston Dam under Alternative 2 are similar to under the No Action Alternative, in most year types, and in most months, as shown in Table 5-42. In extremely wet, wet, normal, and dry years, the monthly average water temperatures for Alternative 2 were within +/-1.0°F (less than 2 percent) of No Action conditions. For the critically dry years, temperatures were 1.7°F (3 percent) cooler in September.

Table 5-42. Changes in Trinity River Water Temperature Below Lewiston Dam Under Alternative 2 as Compared to the No Action Alternative, by Trinity Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (°F)												
Extremely Wet	52.4	50.9	47.8	45.4	45.3	45.8	47.7	46.2	47.8	51.0	53.1	50.4
Wet	52.3	51.8	49.3	48.1	47.3	49.7	51.2	46.6	49.5	52.3	52.2	51.8
Normal	54.8	54.2	49.2	47.4	48.5	51.9	54.6	46.7	51.3	51.9	53.3	53.3
Dry	53.1	51.7	50.5	49.5	49.7	52.0	53.3	49.4	53.2	52.8	53.3	54.0
Critically Dry	55.0	50.2	50.4	51.1	51.9	51.3	52.9	52.0	54.9	54.9	57.5	57.5
Average All Years	53.0	51.7	49.5	48.2	48.2	50.0	51.7	47.8	50.9	52.4	53.2	52.9
Alternative 2 (°F)												
Extremely Wet	52.6	50.9	47.8	45.4	45.3	45.8	47.7	46.2	47.7	51.0	52.8	50.6
Wet	52.4	52.2	49.4	48.1	47.3	49.7	51.1	46.5	49.5	52.2	52.3	51.7
Normal	55.6	54.6	50.1	47.8	48.5	51.9	54.6	46.7	51.3	52.3	52.9	52.6
Dry	53.2	51.7	50.1	49.6	49.7	52.0	53.3	49.8	53.3	52.6	53.1	53.7
Critically Dry	55.2	50.2	50.4	51.0	51.8	51.6	52.8	52.6	55.7	54.5	56.6	55.7
Average All Years	53.2	51.8	49.5	48.3	48.2	50.1	51.6	48.0	51.0	52.3	53.0	52.6
No Action Compared to Alternative 2 (°F)												
Extremely Wet	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	-0.4	0.2
Wet	0.0	0.4	0.0	0.0	0.0	0.0	-0.1	0.0	0.1	-0.2	0.1	0.0
Normal	0.8	0.3	0.9	0.4	0.0	0.0	0.0	0.1	0.0	0.4	-0.4	-0.7
Dry	0.1	0.0	-0.4	0.1	0.1	0.0	0.0	0.4	0.1	-0.2	-0.2	-0.4
Critically Dry	0.3	0.1	-0.1	-0.1	-0.1	0.4	0.0	0.6	0.8	-0.3	-0.9	-1.7
Average All Years	0.1	0.2	0.0	0.1	0.0	0.0	0.0	0.2	0.1	-0.1	-0.2	-0.3
No Action Compared to Alternative 2 (%)												
Extremely Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-1%	0%
Wet	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Normal	1%	1%	2%	1%	0%	0%	0%	0%	0%	1%	-1%	-1%
Dry	0%	0%	-1%	0%	0%	0%	0%	1%	0%	0%	0%	-1%
Critically Dry	0%	0%	0%	0%	0%	1%	0%	1%	1%	-1%	-2%	-3%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-1%

Key:
% = percent
ºF = degrees Fahrenheit

Temperatures at Douglas City under Alternative 2 are similar to under the No Action Alternative, in most year types and in most months, as shown in Table 5-43. In extremely wet, wet, normal, and dry years, the monthly average water temperatures for Alternative 2 were within +/-1.0°F (less than 2 percent) of No Action conditions. For the critically dry years, temperatures were 1.7°F (3 percent) cooler in September.

Table 5-43. Changes in Trinity River Water Temperature at Douglas City Under Alternative 2 as Compared to the No Action Alternative, by Trinity Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (°F)												
Extremely Wet	52.2	49.3	46.0	43.2	44.3	44.9	46.8	47.1	48.6	52.5	54.8	51.4
Wet	52.1	50.2	47.0	45.1	45.3	47.8	49.5	47.2	50.3	53.5	53.5	52.3
Normal	54.4	51.5	45.9	43.9	45.3	47.1	52.7	47.1	52.0	52.9	54.1	53.7
Dry	52.8	50.2	47.8	46.4	46.4	48.8	51.9	49.8	54.1	54.2	54.1	54.2
Critically Dry	54.5	49.3	48.4	48.3	48.7	48.5	51.3	52.2	55.4	56.0	57.7	57.4
Average All Years	52.7	50.1	47.1	45.3	45.7	47.6	50.2	48.4	51.8	53.7	54.3	53.3
Alternative 2 (°F)												
Extremely Wet	52.3	49.3	46.0	43.2	44.3	44.9	46.8	47.1	48.5	52.5	54.5	51.6
Wet	52.2	50.5	47.0	45.1	45.3	47.8	49.5	47.2	50.4	53.4	53.5	52.3
Normal	55.1	51.6	46.2	44.0	45.3	47.1	52.7	47.2	52.0	53.2	53.6	52.8
Dry	52.8	50.2	47.5	46.5	46.5	48.8	51.9	50.2	54.3	54.0	53.8	53.8
Critically Dry	54.7	49.4	48.4	48.2	48.6	48.7	51.3	52.8	56.2	55.7	56.8	55.7
Average All Years	52.9	50.2	47.0	45.4	45.7	47.6	50.2	48.6	51.9	53.6	54.1	52.9
No Action Compared to Alternative 2 (°F)												
Extremely Wet	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	-0.3	0.2
Wet	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.1	-0.1	0.0	-0.1
Normal	0.7	0.2	0.3	0.1	0.0	0.0	0.0	0.1	0.0	0.4	-0.5	-0.9
Dry	0.1	0.0	-0.3	0.1	0.0	0.0	0.0	0.4	0.2	-0.1	-0.3	-0.4
Critically Dry	0.2	0.1	-0.1	-0.1	-0.1	0.2	0.0	0.6	0.8	-0.3	-0.9	-1.7
Average All Years	0.1	0.1	-0.1	0.0	0.0	0.0	0.0	0.2	0.1	-0.1	-0.3	-0.3
No Action Compared to Alternative 2 (%)												
Extremely Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-1%	0%
Wet	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Normal	1%	0%	1%	0%	0%	0%	0%	0%	0%	1%	-1%	-2%
Dry	0%	0%	-1%	0%	0%	0%	0%	1%	0%	0%	-1%	-1%
Critically Dry	0%	0%	0%	0%	0%	0%	0%	1%	2%	-1%	-2%	-3%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-1%

Key:
% = percent
ºF = degrees Fahrenheit

At the North Fork Trinity River, South Fork Trinity River and the Trinity River's mouth at Weitchpec (Table 5-44 and Table 5-46, respectively), differences in temperature for all year types, for all months, were less than +/-1°F (1 percent), with the exception of normal, dry, and critically dry year types in August and September, when temperatures were up to 4°F (6 percent), 6.3ºF (9 percent), and 6.6°F (9 percent) cooler for North Fork Trinity River, South Fork Trinity River and mouth locations, respectively. Alternative 2 daily average water temperatures were consistently cooler than No Action conditions. Decreased temperatures in August and September were because of increased flows (due to augmentation releases from Lewiston Dam that were drawn from cool, deep water releases from Trinity Reservoir), while minor increases or decreases in the other months of the year were due to changes in Trinity Lake operations, impacting storage in Trinity Lake storage or release rate and residence time in Lewiston Reservoir. An exception is June, in critically dry years, when water temperatures were warmer by 1.6°F (3 percent), 1.4°F (2 percent), and 1.3°F (2 percent) for North Fork Trinity River, South Fork Trinity River and Weitchpec, respectively. These increases in water temperature were due to reduced June flows under this alternative.

Table 5-44. Changes in Trinity River Water Temperature at North Fork Trinity River Under Alternative 2 as Compared to the No Action Alternative, by Trinity Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (°F)												
Extremely Wet	53.9	47.3	43.6	41.9	43.9	45.0	47.6	50.1	52.5	59.7	64.5	58.4
Wet	54.4	48.5	44.3	43.2	44.2	47.7	50.5	50.2	55.2	61.9	63.6	58.9
Normal	56.9	49.0	43.0	41.8	43.8	46.3	54.3	50.2	57.3	61.8	64.1	60.0
Dry	54.7	48.5	44.6	43.8	44.8	48.5	53.8	53.4	61.7	65.4	63.9	60.2
Critically Dry	56.0	47.7	44.3	45.0	46.8	48.0	53.1	55.9	62.4	67.2	66.8	63.5
Average All Years	54.8	48.3	44.2	43.2	44.5	47.4	51.6	51.6	57.5	63.0	64.2	59.7
Alternative 2 (°F)												
Extremely Wet	54.0	47.3	43.6	41.9	43.9	45.0	47.6	50.1	52.5	59.7	64.3	58.5
Wet	54.5	48.7	44.3	43.2	44.2	47.7	50.5	50.2	55.3	61.8	63.3	58.6
Normal	57.4	49.1	43.1	41.9	43.8	46.3	54.3	50.3	57.3	62.0	62.4	56.7
Dry	54.7	48.5	44.4	43.8	44.9	48.5	53.8	54.0	62.1	65.2	62.7	58.2
Critically Dry	56.2	47.7	44.3	45.0	46.8	48.1	53.1	56.7	64.0	67.0	64.6	59.4
Average All Years	54.9	48.3	44.1	43.2	44.5	47.4	51.6	51.9	57.8	63.0	63.4	58.4
No Action Compared to Alternative 2 (°F)												
Extremely Wet	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	-0.2	0.1
Wet	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.1	-0.1	-0.2	-0.2
Normal	0.5	0.1	0.1	0.0	0.0	0.0	0.0	0.1	0.0	0.3	-1.7	-3.4
Dry	0.0	0.0	-0.2	0.0	0.0	0.0	0.0	0.6	0.4	-0.1	-1.2	-2.0
Critically Dry	0.2	0.1	-0.1	-0.1	0.0	0.1	0.0	0.8	1.6	-0.2	-2.1	-4.0
Average All Years	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.3	0.3	-0.1	-0.8	-1.3
No Action Compared to Alternative 2 (%)												
Extremely Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Normal	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-3%	-6%
Dry	0%	0%	0%	0%	0%	0%	0%	1%	1%	0%	-2%	-3%
Critically Dry	0%	0%	0%	0%	0%	0%	0%	1%	3%	0%	-3%	-6%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	-1%	-2%

Key:
% = percent
ºF = degrees Fahrenheit

Table 5-45. Changes in Trinity River Water Temperature at South Fork Trinity River Under Alternative 2 as Compared to the No Action Alternative, by Trinity Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (°F)												
Extremely Wet	56.7	49.0	44.7	43.3	46.2	47.5	49.6	54.2	57.9	66.6	72.2	66.0
Wet	57.7	50.0	44.9	44.4	45.9	49.7	52.7	53.8	60.4	68.4	72.0	65.4
Normal	59.3	50.9	44.2	42.7	44.5	47.6	57.3	54.0	62.6	68.9	72.1	66.1
Dry	58.0	49.7	44.8	44.0	45.8	50.0	55.9	57.3	67.2	74.0	72.5	66.1
Critically Dry	58.8	47.8	42.9	44.3	46.9	48.8	54.5	58.8	66.5	75.2	74.1	69.1
Average All Years	57.9	49.6	44.6	43.9	45.9	49.1	53.7	55.4	62.8	70.4	72.4	66.1
Alternative 2 (°F)												
Extremely Wet	56.8	49.0	44.7	43.3	46.2	47.5	49.6	54.2	57.9	66.6	72.1	66.0
Wet	57.7	50.1	44.9	44.4	45.9	49.7	52.7	53.8	60.6	68.4	71.6	65.0
Normal	59.6	50.9	44.2	42.7	44.5	47.6	57.3	54.2	62.6	69.0	69.8	60.7
Dry	58.0	49.7	44.7	44.0	45.8	50.0	55.9	57.9	67.7	74.0	70.7	62.6
Critically Dry	58.9	47.8	42.9	44.3	46.9	48.9	54.5	59.4	67.9	75.2	71.2	62.7
Average All Years	57.9	49.6	44.6	43.9	45.9	49.1	53.7	55.7	63.1	70.4	71.2	63.8
No Action Compared to Alternative 2 (°F)												
Extremely Wet	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.0
Wet	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	-0.4	-0.4
Normal	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	-2.4	-5.5
Dry	0.0	0.0	-0.1	0.0	0.0	0.0	0.0	0.6	0.4	0.0	-1.8	-3.5
Critically Dry	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.6	1.4	-0.1	-3.0	-6.3
Average All Years	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.0	-1.2	-2.2
No Action Compared to Alternative 2 (%)												
Extremely Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-1%	-1%
Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-3%	-8%
Dry	0%	0%	0%	0%	0%	0%	0%	1%	1%	0%	-2%	-5%
Critically Dry	0%	0%	0%	0%	0%	0%	0%	1%	2%	0%	-4%	-9%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-2%	-3%

Key:
% = percent
ºF = degrees Fahrenheit

Table 5-46. Changes in Trinity River Water Temperature at Mouth of Trinity River (Weitchpec) Under Alternative 2 as Compared to the No Action Alternative, by Trinity Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (°F)												
Extremely Wet	56.7	48.8	44.7	43.4	46.3	47.6	49.8	54.6	58.3	67.1	72.4	66.3
Wet	57.7	49.6	44.9	44.5	46.1	49.8	52.9	54.3	61.1	69.0	72.7	65.9
Normal	59.5	50.7	44.2	42.8	44.6	47.7	57.4	54.6	63.5	69.7	73.0	67.0
Dry	58.0	49.4	44.6	44.0	45.9	50.1	56.2	57.9	67.8	75.0	73.7	66.8
Critically Dry	58.6	47.7	42.6	44.1	47.0	49.0	54.9	59.5	67.3	76.2	75.2	69.9
Average All Years	57.9	49.3	44.5	44.0	46.0	49.3	53.9	55.9	63.4	71.2	73.2	66.7
Alternative 2 (°F)												
Extremely Wet	56.7	48.8	44.7	43.4	46.3	47.6	49.8	54.6	58.3	67.1	72.3	66.3
Wet	57.7	49.7	44.9	44.5	46.1	49.8	52.9	54.3	61.2	69.0	72.4	65.5
Normal	59.7	50.7	44.3	42.8	44.6	47.7	57.4	54.8	63.5	69.8	70.9	61.2
Dry	58.1	49.4	44.6	44.0	46.0	50.1	56.2	58.5	68.3	74.9	72.0	63.2
Critically Dry	58.7	47.7	42.6	44.1	46.9	49.0	54.9	60.0	68.6	76.1	72.3	63.3
Average All Years	57.9	49.4	44.5	44.0	46.0	49.3	53.9	56.2	63.7	71.2	72.1	64.4
No Action Compared to Alternative 2 (°F)												
Extremely Wet	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.0
Wet	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	-0.4	-0.4
Normal	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.1	-2.1	-5.7
Dry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.4	0.0	-1.7	-3.7
Critically Dry	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.5	1.3	-0.1	-2.8	-6.6
Average All Years	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.3	0.0	-1.1	-2.3
No Action Compared to Alternative 2 (%)												
Extremely Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-1%	-1%
Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-3%	-9%
Dry	0%	0%	0%	0%	0%	0%	0%	1%	1%	0%	-2%	-5%
Critically Dry	0%	0%	0%	0%	0%	0%	0%	1%	2%	0%	-4%	-9%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-1%	-4%

Key:
% = percent
ºF = degrees Fahrenheit

Potential impacts on existing temperature objectives in the Trinity River (Table 5-3) were assessed for the specific periods when objectives were applicable. A comparison of No Action versus Alternative 2 for the 1980 to 2003 RBM10 simulation period was completed to assess the frequency (number of days) of meeting temperature objectives based on daily average water temperature.

However, there were periods objectives were not met, including:

- Increased frequency of meeting objectives under Alternative 2 compared to the No Action
- Decreased frequency of meeting objectives under Alternative 2 compared to the No Action than Alternative 1
- Equal frequency of meeting objectives for both No Action and Alternative2.

The number of days that the objectives were not achieved is summarized in tabular form for the stipulated temperature objectives (i.e., temperature for each location and time period).

Non-compliance days for the Trinity River at Douglas City (between July 1 and September 30) are shown in Table 5-47. Temperature objectives at this location were largely met, except in drier year types. Non-compliance for No Action and Alternative 2 occurred 40 and 46 days, respectively, between July 1 and September 15. Non-compliance for No Action and Alternative 2 occurred 27 and 31 days, respectively, between September 15 and September 30. The difference in non-compliance, between No Action and Alternative 2 at Douglas City, was 1 percent or less.

Table 5-47. Number of Days that No Action Alternative and Alternative 2 Temperatures at Douglas City Exceeded Basin Plan Temperature Objectives

Basin Plan Temperature Objective: Lewiston to Douglas City (RM 111 to RM 92)		**7/1 to 9/15 ≤ 60 °F**		**9/15 to 9/30 ≤ 56 °F**	
Year	**Trinity Water Year Type**	**No Action**	**Alt. 2**	**No Action**	**Alt. 2**
1980	W	0	0	0	0
1981	D	0	0	0	0
1982	EW	0	0	0	0
1983	EW	0	0	0	0
1984	W	0	0	0	0
1985	D	0	0	0	0
1986	W	0	0	0	0
1987	D	0	0	0	0
1988	D	0	0	0	0
1989	N	0	0	0	0
1990	D	0	0	7	**6**
1991	CD	33	**12**	15	15
1992	D	0	0	5	**1**
1993	W	1	**<u>2</u>**	0	0
1994	CD	0	0	0	0
1995	EW	6	6	0	0
1996	W	0	0	0	0
1997	W	0	0	0	0
1998	EW	0	0	0	0
1999	W	0	0	0	0
2000	W	0	0	0	0
2001	D	0	0	0	0
2002	N	0	0	0	0
2003	EW	0	0	0	0
# of Days of Non-compliance		40	20	27	22
Total # of Days		1,848	1,848	384	384
%		2%	1%	7%	6%

Note:
Bold values denote less days of non-compliance and **<u>bold underline</u>** values denote more days of non-compliance

Key:
% = percent
ºF = degrees Fahrenheit
CD = critically dry
D = dry
EW = extremely wet
N = normal
RM = River Mile
W = wet

Non-compliance days for the Trinity River below North Fork Trinity River (between October 1 and December 31) are shown in Table 5-48. Temperature objectives at this location were not met

as often as at Douglas City. Non-compliance for No Action and Alternative 2 occurred 244 and 260 days, respectively, between October 1 and December 31. The difference in non-compliance, between No Action and Alternative 2 at North Fork Trinity River, was 1 percent.

Table 5-48. Number of Days that No Action Alternative and Alternative 2 Temperatures at Trinity River Below North Fork Trinity River Exceeded Basin Plan Temperature Objectives

Basin Plan Temperature Objective: Lewiston to North Fork Trinity River Confluence (RM 111 to RM 72)		**10/1 to 12/31 ≤ 56 °F**	
Year	**Trinity Water Year Type**	**No Action**	**Alt. 2**
1980	W	10	10
1981	D	1	**3**
1982	EW	1	1
1983	EW	7	7
1984	W	1	1
1985	D	9	9
1986	W	2	2
1987	D	23	**27**
1988	D	22	**24**
1989	N	20	20
1990	D	11	**12**
1991	CD	22	22
1992	D	26	**<u>19</u>**
1993	W	10	**12**
1994	CD	14	**15**
1995	EW	0	0
1996	W	11	11
1997	W	1	1
1998	EW	1	1
1999	W	8	8
2000	W	9	9
2001	D	19	**21**
2002	N	6	**15**
2003	EW	10	10
# of Days of Non-compliance		244	260
Total # of Days		2,208	2,208
%		11%	12%

Note:
Bold values denote less days of non-compliance and **<u>bold underline</u>** values denote more days of non-compliance

Key:
% = percent
ºF = degrees Fahrenheit
CD = critically dry
D = dry
EW = extremely wet
N = normal
RM = River Mile
W = wet

The springtime objectives from the ROD for the Trinity River Trinity River Mainstem Fishery Restoration EIS/EIR (DOI and Hoopa Valley 2000) were also assessed. These daily average water temperature objectives are applicable to the Trinity River, from Lewiston Dam to its confluence with the Klamath River. For this analysis, the number of non-compliance days for No Action and Alternative 2 were compared for all years in the RBM10 simulation. Five locations were assessed: Trinity River below Lewiston Dam, Trinity River at Douglas City, Trinity River below North Fork Trinity River, Trinity River below North Fork Trinity River, and Trinity River near Weitchpec (Table 5-49 through Table 5-53, respectively). For the Trinity River (below Lewiston Dam and at Douglas City) there were few incidences of temperatures exceeding objectives—only a few days between April 15 and May 22. At the North Fork Trinity River the number of days increased slightly, but at the South Fork Trinity River and mouth locations, there was a high prevalence of non-compliance—with percentage of time exceeding objectives ranging from 18 percent to 99 percent—with dry and critically dry years experiencing the highest percentages in June. There was no difference between the No Action and Alternative 2 below Lewiston Dam and Douglas City. At the North Fork Trinity River, dry and critically dry year types increased in non-compliance from 6 to 10 days in June—less than 1 percent of all days—for Alternative 2 versus No Action. At the South Fork Trinity and mouth locations, Alternative 2 indicated more days of non-compliance during all three temperature compliance periods (4/15 to 5/22, 5/23 to 6/4, and 6/5 to 6/15 (critically dry and dry) and 6/5 to 7/9 (normal, wet, extremely wet)). For all periods except 6/5 to 6/15 in dry and critically dry years, increases ranged from approximately 1 percent to 4 percent. For the 6/5 to 6/15 period in dry and critically dry years, increased in non-compliance increased approximately 5 percent to 7 percent. These results indicate that these two alternatives were similar in temperature response, with the exception of critically dry and dry years in early June.

Table 5-49. Number of Days that No Action Alternative and Alternative 2 Average Daily Water Temperatures at Trinity River Below Lewiston Dam Exceeded Spring-Time Temperature Objectives

Spring-Time Temperature Objective: Lewiston to Weitchpec (RM 111 to RM 0.1)		**4/15 to 5/22** **≤ 55.4 °F (for N, W & EW years)** **≤ 59.0 °F (for D & CD years)**		**5/23 to 6/4** **≤ 59.0 °F (for N, W & EW years)** **≤ 62.6 °F (for D & CD years)**		**6/5 to 7/9** **≤ 62.6 °F (for N, W & EW years)** **6/5 to 6/15** **≤ 68.0 °F (for D & CD years)**	
Year	**Trinity Water Year Type**	**No Action**	**Alt. 2**	**No Action**	**Alt. 2**	**No Action**	**Alt. 2**
1980	W	6	6	0	0	0	0
1981	D	0	0	0	0	0	0
1982	EW	0	0	0	0	0	0
1983	EW	0	0	0	0	0	0
1984	W	0	0	0	0	0	0
1985	D	0	0	0	0	0	0
1986	W	0	0	0	0	0	0
1987	D	0	0	0	0	0	0
1988	D	0	0	0	0	0	0
1989	N	8	8	0	0	0	0
1990	D	0	0	0	0	0	0
1991	CD	0	0	0	0	0	0
1992	D	0	0	0	0	0	0
1993	W	0	0	0	0	0	0
1994	CD	0	0	0	0	0	0
1995	EW	0	0	0	0	0	0
1996	W	0	0	0	0	0	0
1997	W	0	0	0	0	0	0
1998	EW	0	0	0	0	0	0
1999	W	5	5	0	0	0	0
2000	W	0	0	0	0	0	0
2001	D	0	0	0	0	0	0
2002	N	0	0	0	0	0	0
2003	EW	0	0	0	0	0	0
# of days of Non-compliance		19	19	0	0	0	0
Total # of Days		888	888	360	360	840 (N/W/EW) 99 (D/CD)	840 (N/W/EW) 99 (D/CD)
%		2%	2%	0%	0%	0%/0%	0%/0%

Key:
% = percent
ºF = degrees Fahrenheit
CD = critically dry
D = dry
EW = extremely wet
N = normal
RM = River Mile
W = wet

Table 5-50. Number of Days that No Action Alternative and Alternative 2 Temperatures at Trinity River near Douglas City Exceeded Spring-Time Temperature Objectives

Spring-Time Temperature Objective: Lewiston to Weitchpec (RM 111 to RM 0.1)		**4/15 to 5/22** **≤ 55.4 °F (for N, W & EW years)** **≤ 59.0 °F (for D & CD years)**		**5/23 to 6/4** **≤ 59.0 °F (for N, W & EW years)** **≤ 62.6 °F (for D & CD years)**		**6/5 to 7/9** **≤ 62.6 °F (for N, W & EW years)** **6/5 to 6/15** **≤ 68.0 °F (for D & CD years)**	
Year	**Trinity Water Year Type**	**No Action**	**Alt. 2**	**No Action**	**Alt. 2**	**No Action**	**Alt. 2**
1980	W	0	0	0	0	0	0
1981	D	0	0	0	0	0	0
1982	EW	0	0	0	0	0	0
1983	EW	0	0	0	0	0	0
1984	W	0	0	0	0	0	0
1985	D	0	0	0	0	0	0
1986	W	0	0	0	0	0	0
1987	D	0	0	0	0	0	0
1988	D	0	0	0	0	0	0
1989	N	7	7	0	0	0	0
1990	D	0	0	0	0	0	0
1991	CD	0	0	0	0	0	0
1992	D	0	0	0	0	0	0
1993	W	0	0	0	0	0	0
1994	CD	0	0	0	0	0	0
1995	EW	0	0	0	0	0	0
1996	W	0	0	0	0	0	0
1997	W	0	0	0	0	0	0
1998	EW	0	0	0	0	0	0
1999	W	0	0	0	0	0	0
2000	W	0	0	0	0	0	0
2001	D	0	0	0	0	0	0
2002	N	0	0	0	0	0	0
2003	EW	0	0	0	0	0	0
# of days of Non-compliance		7	7	0	0	0	0
Total # of Days		888	888	360	360	840 (N/W/EW) 99 (D/CD)	840 (N/W/EW) 99 (D/CD)
%		1%	1%	0%	0%	0%/0%	0%/0%

Key:
% = percent
ºF = degrees Fahrenheit
CD = critically dry
D = dry
EW = extremely wet
N = normal
RM = River Mile
W = wet

Table 5-51. Number of Days that No Action Alternative and Alternative 2 Temperatures at Trinity River at the North Fork Trinity River Exceeded Spring-Time Temperature Objectives

Spring-Time Temperature Objective: Lewiston to Weitchpec (RM 111 to RM 0.1)		**4/15 to 5/22** **≤ 55.4 °F (for N, W & EW years)** **≤ 59.0 °F (for D & CD years)**		**5/23 to 6/4** **≤ 59.0 °F (for N, W & EW years)** **≤ 62.6 °F (for D & CD years)**		**6/5 to 7/9** **≤ 62.6 °F (for N, W & EW years)** **6/5 to 6/15** **≤ 68.0 °F (for D & CD years)**	
Year	**Trinity Water Year Type**	**No Action**	**Alt. 2**	**No Action**	**Alt. 2**	**No Action**	**Alt. 2**
1980	W	2	2	0	0	0	0
1981	D	0	0	0	0	1	1
1982	EW	0	0	0	0	0	0
1983	EW	1	1	0	0	0	0
1984	W	0	0	0	0	0	0
1985	D	0	0	0	0	0	1
1986	W	0	0	0	0	0	0
1987	D	1	1	0	0	0	0
1988	D	0	0	0	0	2	3
1989	N	7	7	0	0	0	0
1990	D	0	0	0	0	0	0
1991	CD	0	0	0	0	0	0
1992	D	0	0	1	2	3	5
1993	W	0	0	0	0	0	0
1994	CD	7	7	0	5	0	0
1995	EW	0	0	0	0	0	0
1996	W	0	0	0	0	0	0
1997	W	0	0	0	0	0	0
1998	EW	0	0	0	0	0	0
1999	W	3	3	0	0	0	0
2000	W	0	0	0	0	0	0
2001	D	3	3	0	1	0	0
2002	N	3	3	0	0	0	0
2003	EW	0	0	0	0	0	0
# of days of Non-compliance		27	27	1	8	0/6	0/10
Total # of Days		888	888	360	360	840 (N/W/EW) 99 (D/CD)	840 (N/W/EW) 99 (D/CD)
%		3%	3%	0%	2%	0%/6%	0%/10%

Key:
% = percent
ºF = degrees Fahrenheit
CD = critically dry
D = dry
EW = extremely wet
N = normal
RM = River Mile
W = wet

Table 5-52. Number of Days that No Action Alternative and Alternative 2 Temperatures at Trinity River Below South Fork Trinity River Exceeded Spring-Time Temperature Objectives

Spring-Time Temperature Objective: Lewiston to Weitchpec (RM 111 to RM 0.1)		**4/15 to 5/22** **≤ 55.4 °F (for N, W & EW years)** **≤ 59.0 °F (for D & CD years)**		**5/23 to 6/4** **≤ 59.0 °F (for N, W & EW years)** **≤ 62.6 °F (for D & CD years)**		**6/5 to 7/9** **≤ 62.6 °F (for N, W & EW years)** **6/5 to 6/15** **≤ 68.0 °F (for D & CD years)**	
Year	**Trinity Water Year Type**	**No Action**	**Alt. 2**	**No Action**	**Alt. 2**	**No Action**	**Alt. 2**
1980	W	24	24	0	0	0	0
1981	D	4	4	8	8	0	0
1982	EW	22	22	0	0	0	1
1983	EW	6	6	7	7	2	2
1984	W	3	3	0	0	21	21
1985	D	4	6	0	1	5	5
1986	W	6	6	3	3	14	16
1987	D	16	19	2	2	3	3
1988	D	2	3	0	3	0	0
1989	N	15	15	3	3	24	25
1990	D	9	9	0	0	0	0
1991	CD	0	1	0	5	3	6
1992	D	4	11	11	12	5	6
1993	W	7	7	0	0	23	23
1994	CD	16	17	11	12	2	6
1995	EW	4	4	0	0	14	14
1996	W	13	13	1	1	17	17
1997	W	23	23	0	1	9	9
1998	EW	18	18	0	0	4	4
1999	W	10	10	0	0	17	18
2000	W	6	6	0	0	19	19
2001	D	11	14	11	12	0	0
2002	N	10	10	6	6	18	18
2003	EW	0	0	0	0	5	5
# of days of Non-compliance		233	251	63	76	187/18	192/26
Total # of Days		888	888	360	360	840 (N/W/EW) 99 (D/CD)	840 (N/W/EW) 99 (D/CD)
%		26%	28%	18%	21%	22%/18%	23%/26%

Key:
% = percent
ºF = degrees Fahrenheit
CD = critically dry
D = dry
EW = extremely wet
N = normal
RM = River Mile
W = wet

Table 5-53. Number of Days that No Action Alternative and Alternative 2 Temperatures at Trinity River near Mouth (Weitchpec) Exceeded Spring-Time Temperature Objectives

Spring-Time Temperature Objective: Lewiston to Weitchpec (RM 111 to RM 0.1)		**4/15 to 5/22** **≤ 55.4 °F (for N, W & EW years)** **≤ 59.0 °F (for D & CD years)**		**5/23 to 6/4** **≤ 59.0 °F (for N, W & EW years)** **≤ 62.6 °F (for D & CD years)**		**6/5 to 7/9** **≤ 62.6 °F (for N, W & EW years)** **6/5 to 6/15** **≤ 68.0 °F (for D & CD years)**	
Year	**Trinity Water Year Type**	**No Action**	**Alt. 2**	**No Action**	**Alt. 2**	**No Action**	**Alt. 2**
1980	W	24	24	0	0	10	10
1981	D	4	4	8	9	0	0
1982	EW	23	23	0	0	1	1
1983	EW	7	7	8	8	3	3
1984	W	4	4	0	1	24	24
1985	D	4	6	0	5	5	5
1986	W	7	7	4	5	20	20
1987	D	18	19	3	3	4	6
1988	D	3	3	2	5	0	0
1989	N	19	19	3	3	30	32
1990	D	9	9	0	0	0	0
1991	CD	1	1	2	3	4	7
1992	D	10	17	12	12	7	7
1993	W	10	10	0	0	23	23
1994	CD	18	19	12	12	4	7
1995	EW	5	5	0	0	14	14
1996	W	14	14	1	1	20	20
1997	W	28	28	1	1	16	16
1998	EW	18	18	0	0	5	6
1999	W	10	10	2	3	20	23
2000	W	8	8	0	0	20	20
2001	D	13	15	13	13	0	0
2002	N	12	12	6	6	30	32
2003	EW	0	0	0	0	12	13
# of days of Non-compliance		269	282	77	90	248/24	257/32
Total # of Days		888	888	360	360	840 (N/W/EW) 99 (D/CD)	840 (N/W/EW) 99 (D/CD)
%		30%	32%	21%	25%	30%/24%	31%/32%

Key:
% = percent
ºF = degrees Fahrenheit
CD = critically dry
D = dry
EW = extremely wet
N = normal
RM = River Mile
W = wet

Klamath River Below Trinity River The temperature impacts associated with Alternative 2 for Klamath River temperatures (near Klamath) were evaluated by comparing the simulated temperatures of the No Action Alternative and Alternative 2. A comparison of daily water temperature (averaged by month for Alternative 2 and No Action temperatures) is presented for each location, and tabular monthly averages are presented in Table 5-54. The alternatives identified herein do not increase the water temperature by 5ºF (NCRWQCB 2011). There are no temperature objectives for the lower Klamath River.

Water temperatures at Klamath River (near Klamath) under Alternative 2 were similar to the No Action Alternative in most all year types, and in most months, except August and September. In extremely wet and wet years, the monthly average water temperatures for Alternative 1 were within +/-0.5ºF (less than 1 percent) of No Action conditions. For the normal, dry, and critically dry years temperatures were 1.9ºF (3 percent) to 4.0ºF (6 percent) cooler. Temperatures in the Klamath River (at Klamath) did not exhibit the same magnitude of cooling due to water comingling and heating from the confluence of the Trinity River through to the Klamath River Estuary.

Table 5-54. Changes in Klamath River near Klamath Water Temperature Under Alternative 2 as Compared to the No Action Alternative, by Trinity Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (°F)												
Extremely Wet	56.6	48.6	43.7	42.7	45.6	47.6	49.9	56.2	61.4	69.3	72.5	67.1
Wet	57.6	49.5	43.7	43.3	45.2	49.4	52.7	56.3	63.9	71.2	73.0	66.6
Normal	59.9	50.4	43.4	42.0	43.6	47.5	56.7	56.9	66.2	72.0	73.1	67.7
Dry	58.0	49.4	43.6	43.2	45.4	50.4	56.4	60.2	69.1	75.5	73.8	67.2
Critically Dry	58.5	48.6	42.2	43.1	46.7	49.8	55.5	60.6	68.3	76.9	74.4	69.7
Average All Years	57.8	49.3	43.5	43.0	45.3	49.3	53.9	57.9	65.6	72.7	73.3	67.2
Alternative 2 (°F)												
Extremely Wet	56.7	48.6	43.7	42.7	45.6	47.6	49.9	56.2	61.5	69.3	72.5	67.1
Wet	57.6	49.5	43.7	43.3	45.2	49.4	52.7	56.3	64.0	71.2	72.8	66.4
Normal	59.9	50.4	43.4	42.0	43.6	47.5	56.7	57.0	66.3	72.1	72.0	64.2
Dry	58.0	49.4	43.6	43.2	45.4	50.4	56.4	60.6	69.3	75.4	72.9	65.3
Critically Dry	58.5	48.6	42.2	43.1	46.7	49.9	55.5	60.9	69.0	76.9	72.8	65.7
Average All Years	57.9	49.3	43.5	43.0	45.3	49.3	53.9	58.1	65.8	72.7	72.7	65.9
No Action Compared to Alternative 2 (°F)												
Extremely Wet	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wet	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	-0.2	-0.2
Normal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	-1.1	-3.5
Dry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.2	0.0	-0.9	-1.9
Critically Dry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.7	0.0	-1.6	-4.0
Average All Years	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.0	-0.6	-1.3
No Action Compared to Alternative 2 (%)												
Extremely Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-2%	-5%
Dry	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	-1%	-3%
Critically Dry	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	-2%	-6%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-1%	-2%

Key:
% = percent
ºF = degrees Fahrenheit

Changes in Nutrients, Organic Matter, and Dissolved Oxygen

Trinity River: Lewiston Dam to Klamath River For the Trinity River under Alternative 2, nutrient concentrations, organic matter and DO would be similar to the No Action Alternative because all releases from Trinity Reservoir would be of similar quality. During the spring period when releases from Trinity Reservoir to the Trinity River would be lower than Alternative 2 than under No Action, flows are typically still high in response to snowmelt runoff from adjacent watershed areas in both the Klamath and Trinity Rivers (i.e., several 1,000 cubic feet per second (cfs)). Thus, reduced flows from Trinity Reservoir would have a modest impact on Trinity River nutrients and organic matter. DO conditions would be similar under Alternative 2 and No Action due to mechanical reaeration throughout much of this reach.

Klamath River: Below Trinity River For the lower Klamath River, under Alternative 2, lower nutrient and organic matter concentrations would be anticipated during August and September in comparison to the No Action Alternative. The Trinity River typically experiences lower nutrients and organic matter conditions than the Klamath River. Thus, during periods when augmentation flows occur, contributions from the Trinity River will result in lower nutrient and organic matter concentrations in the Klamath River below the Trinity River confluence due to dilution effects. During the spring period flows are typically still high in response to snowmelt runoff from adjacent watershed areas in both the Klamath and Trinity Rivers (i.e., several 1,000 cfs), minimizing any impacts on nutrients and organic matter concentrations. Concentration of blue-green algae is expected to be similar or lower in comparison to the No Action Alternative because high temperature and nutrient conditions that contribute to algal blooms would not increase in frequency or magnitude.

For the lower Klamath River, under Alternative 2, similar DO concentrations would be anticipated during August and September in comparison to the No Action Alternative. This is because mechanical reaeration maintains both rivers at or near saturation concentration. Because DO saturation concentration is a function of water temperature, the lower Klamath River may experience slightly lower DO concentrations during augmentation due to slightly cooler water temperatures.

Central Valley and Bay-Delta Region

Changes in Water Temperature

Sacramento River Below Keswick Dam Water temperatures on the Sacramento River are summarized in Table 5-55 through Table 5-58. Water temperatures on the Sacramento River, below Clear Creek and at Balls Ferry, Jellys Ferry, and Bend Bridge under Alternative 2, would be similar to the No Action Alternative with all months, of all year types, changing less than, or equal to, 1 percent.

Table 5-55. Changes in Water Temperature on Sacramento River Below Clear Creek Under Alternative 2 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (°F)												
Wet	55.1	54.8	50.7	47.0	45.9	46.6	48.5	50.1	51.0	51.9	53.2	52.0
Above Normal	55.9	54.8	50.8	47.4	46.2	47.4	49.0	50.5	50.7	51.3	52.8	52.6
Below Normal	55.1	55.0	51.5	48.1	47.3	48.9	49.9	50.8	51.3	52.3	53.6	54.9
Dry	55.8	55.0	51.2	48.3	47.8	49.0	50.3	51.1	51.5	52.9	54.9	55.9
Critical	58.4	56.1	51.7	47.9	47.6	49.4	50.3	52.6	54.1	56.0	59.1	62.3
Average All Years	55.9	55.1	51.1	47.7	46.9	48.1	49.5	50.9	51.6	52.7	54.5	55.0
Alternative 2 (°F)												
Wet	55.1	54.8	50.7	47.0	45.9	46.6	48.5	50.1	51.0	51.9	53.1	52.0
Above Normal	55.9	54.9	50.9	47.4	46.2	47.4	49.0	50.5	50.7	51.3	52.8	52.6
Below Normal	55.0	55.0	51.5	48.1	47.3	48.9	49.9	50.8	51.4	52.3	53.6	54.9
Dry	55.7	54.9	51.2	48.3	47.8	49.0	50.3	51.1	51.5	52.9	54.8	55.8
Critical	58.5	56.1	51.7	47.8	47.6	49.4	50.3	52.6	54.2	56.0	59.0	62.5
Average All Years	55.9	55.1	51.1	47.7	46.9	48.1	49.5	50.9	51.6	52.7	54.4	55.0
No Action Compared to Alternative 2 (°F)												
Wet	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.0
Above Normal	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Below Normal	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0
Dry	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1
Critical	0.1	0.0	0.0	-0.1	0.0	0.0	0.0	0.0	0.1	0.0	-0.1	0.2
Average All Years	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.0
No Action Compared to Alternative 2 (%)												
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Below Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Critical	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Key:
% = percent
ºF = degrees Fahrenheit

Table 5-56. Changes in Water Temperature on Sacramento River at Balls Ferry Under Alternative 2 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (°F)												
Wet	55.6	54.3	49.7	46.7	46.2	47.3	50.1	52.4	53.0	53.3	54.5	52.8
Above Normal	56.4	54.4	50.0	47.0	46.4	48.2	50.7	52.5	52.3	52.4	54.0	53.6
Below Normal	55.5	54.5	50.6	47.5	47.5	49.7	51.4	52.5	52.8	53.4	54.7	56.2
Dry	56.2	54.6	50.4	47.8	47.9	49.8	51.9	53.0	52.9	54.1	56.1	57.3
Critical	58.8	55.9	51.0	47.6	48.0	50.4	51.5	54.2	55.5	57.1	60.2	63.3
Average All Years	56.3	54.7	50.2	47.3	47.1	48.8	51.0	52.8	53.2	54.0	55.7	56.1
Alternative 2 (°F)												
Wet	55.6	54.3	49.7	46.7	46.2	47.3	50.0	52.4	53.0	53.4	54.5	52.8
Above Normal	56.4	54.4	50.0	47.0	46.4	48.2	50.7	52.5	52.3	52.4	54.0	53.6
Below Normal	55.5	54.5	50.6	47.5	47.5	49.7	51.4	52.5	52.9	53.4	54.7	56.2
Dry	56.2	54.6	50.4	47.8	47.9	49.8	51.9	53.0	52.9	54.1	56.0	57.2
Critical	58.8	55.9	51.0	47.6	48.0	50.4	51.5	54.2	55.5	57.1	60.0	63.5
Average All Years	56.3	54.7	50.2	47.2	47.1	48.8	51.0	52.8	53.2	54.0	55.6	56.1
No Action Compared to Alternative 2 (°F)												
Wet	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	0.1	0.0	0.0
Above Normal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Below Normal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0
Dry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1
Critical	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.2	0.2
Average All Years	0.0	0.0	0.0	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.0
No Action Compared to Alternative 2 (%)												
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Below Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Critical	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Key:
% = percent
ºF = degrees Fahrenheit

Table 5-57. Changes in Water Temperature on Sacramento River at Jellys Ferry Under Alternative 2 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (°F)												
Wet	56.0	53.8	48.9	46.4	46.4	48.1	51.6	54.7	55.4	55.1	56.1	53.8
Above Normal	56.9	54.0	49.2	46.6	46.6	49.0	52.2	54.9	54.3	53.8	55.4	54.8
Below Normal	56.0	54.0	49.6	46.9	47.6	50.4	53.0	54.4	54.5	54.8	56.0	57.7
Dry	56.6	54.2	49.6	47.3	47.9	50.4	53.4	55.0	54.5	55.4	57.5	58.9
Critical	59.0	55.5	50.2	47.2	48.3	51.2	52.8	55.9	57.0	58.4	61.3	64.2
Average All Years	56.7	54.2	49.4	46.8	47.2	49.6	52.5	54.9	55.1	55.4	57.1	57.3
Alternative 2 (°F)												
Wet	56.0	53.9	48.9	46.4	46.4	48.1	51.6	54.7	55.4	55.1	56.1	53.8
Above Normal	56.8	54.1	49.2	46.6	46.6	49.0	52.2	54.9	54.3	53.9	55.4	54.8
Below Normal	55.9	54.0	49.6	46.9	47.6	50.4	53.0	54.4	54.6	54.8	56.0	57.8
Dry	56.6	54.2	49.6	47.3	47.9	50.4	53.4	55.0	54.5	55.4	57.5	58.8
Critical	59.1	55.5	50.2	47.2	48.3	51.2	52.8	56.0	57.1	58.4	61.2	64.4
Average All Years	56.7	54.2	49.4	46.8	47.2	49.6	52.5	54.9	55.1	55.4	57.1	57.3
No Action Compared to Alternative 2 (°F)												
Wet	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Above Normal	-0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
Below Normal	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1
Dry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1
Critical	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	-0.1	0.2
Average All Years	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
No Action Compared to Alternative 2 (%)												
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Below Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Critical	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Key:
% = percent
ºF = degrees Fahrenheit

Table 5-58. Changes in Water Temperature on Sacramento River at Bend Bridge Under Alternative 2 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (°F)												
Wet	56.3	53.5	48.5	46.4	46.6	48.6	52.3	55.6	56.4	56.2	57.3	54.6
Above Normal	57.2	53.7	48.8	46.5	46.8	49.7	53.2	55.9	55.4	54.9	56.6	55.7
Below Normal	56.2	53.7	49.1	46.7	47.7	51.0	53.7	55.4	55.6	55.8	57.1	58.8
Dry	56.9	53.8	49.1	47.0	47.9	51.0	54.2	56.1	55.7	56.6	58.7	60.0
Critical	59.3	55.2	49.7	47.0	48.5	51.7	53.6	56.9	58.1	59.5	62.2	64.8
Average All Years	57.0	53.9	49.0	46.7	47.4	50.1	53.3	55.9	56.2	56.5	58.2	58.2
Alternative 2 (°F)												
Wet	56.3	53.5	48.5	46.4	46.6	48.6	52.3	55.6	56.4	56.3	57.2	54.6
Above Normal	57.1	53.7	48.8	46.5	46.8	49.6	53.2	55.9	55.4	54.9	56.6	55.7
Below Normal	56.2	53.7	49.1	46.7	47.7	51.0	53.7	55.5	55.6	55.8	57.1	58.8
Dry	56.9	53.8	49.2	47.0	47.9	51.0	54.2	56.1	55.7	56.6	58.7	60.0
Critical	59.3	55.2	49.7	47.0	48.4	51.7	53.6	56.9	58.1	59.5	62.1	64.9
Average All Years	57.0	53.9	49.0	46.7	47.4	50.1	53.3	55.9	56.2	56.5	58.2	58.2
No Action Compared to Alternative 2 (°F)												
Wet	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	-0.1	0.0
Above Normal	-0.1	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	0.0	0.0	0.0	0.0
Below Normal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
Dry	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Critical	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	0.0	0.0	0.0	-0.1	0.1
Average All Years	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
No Action Compared to Alternative 2 (%)												
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Below Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Critical	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Key:
% = percent
ºF = degrees Fahrenheit

Clear Creek Below Whiskeytown Dam Water temperatures on Clear Creek at Igo are summarized in Table 5-59. Water temperatures on Clear Creek under Alternative 2 would be similar to the No Action Alternative, with all months, of all year types, changing less than, or equal to, 1 percent.

Table 5-59. Changes in Water Temperature on Clear Creek at Igo Under Alternative 2 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (°F)												
Wet	52.2	50.4	46.6	44.5	44.5	45.5	47.2	48.7	50.8	54.8	55.0	52.7
Above Normal	53.4	50.9	46.7	44.7	44.6	45.6	47.3	48.7	50.9	54.8	54.8	52.9
Below Normal	52.4	50.3	46.6	44.3	44.7	46.2	47.9	48.8	51.2	55.1	55.3	53.9
Dry	53.5	50.9	47.1	45.0	45.1	46.4	48.0	49.0	51.4	55.3	56.0	54.5
Critical	55.7	52.9	48.3	45.9	46.1	47.3	49.1	50.8	54.4	56.3	56.9	57.6
Average All Years	53.3	51.0	47.0	44.8	44.9	46.1	47.8	49.1	51.5	55.2	55.5	54.1
Alternative 2 (°F)												
Wet	52.2	50.4	46.6	44.5	44.5	45.5	47.2	48.7	50.8	54.8	55.0	52.7
Above Normal	53.4	51.0	46.7	44.7	44.6	45.6	47.3	48.7	50.9	54.8	54.8	52.8
Below Normal	52.3	50.2	46.6	44.3	44.7	46.2	48.0	49.2	51.4	55.2	55.3	53.9
Dry	53.5	50.9	47.1	45.0	45.1	46.4	48.0	49.0	51.5	55.3	56.0	54.3
Critical	55.6	52.8	48.3	45.9	46.1	47.3	49.0	50.8	54.4	56.2	56.8	57.3
Average All Years	53.2	51.0	47.0	44.8	44.9	46.1	47.8	49.2	51.6	55.2	55.5	54.0
No Action Compared to Alternative 2 (°F)												
Wet	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Above Normal	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1
Below Normal	-0.1	-0.1	0.0	0.0	0.0	0.0	0.1	0.4	0.2	0.1	0.0	0.0
Dry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	-0.2
Critical	-0.1	-0.1	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	-0.1	-0.1	-0.3
Average All Years	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	-0.1
No Action Compared to Alternative 2 (%)												
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Below Normal	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Critical	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-1%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Key:
% = percent
ºF = degrees Fahrenheit

Feather River Below Thermalito/Oroville Dam Temperatures on the Feather River were not modelled, but because Oroville storage and releases change by 1 percent or less in Alternative 2 (as compared to the No Action Alternative) changes in downstream water temperatures are assumed to be similar. See Tables 4-44 and 4-46 in Chapter 4, "Surface Water Supply and Management," for changes in Oroville storage and flows on the Feather River.

American River Below Nimbus Dam Temperatures on the American River were not modelled, but because Folsom storage and releases change by 1 percent or less in Alternative 2 (as compared to the No Action Alternative) changes in downstream water temperatures are assumed to be similar. See Tables 4-48 and 4-50 in Chapter 4, "Surface Water Supply and Management," for changes in Folsom storage and flows on the American River.

Changes in Salinity

Delta Salinity Salinities in the Delta at Rock Slough, Emmaton, Jersey Point, Collinsville, and at Banks and Jones Pumping Plants, are summarized in Table 5-60 through Table 5-65. Salinities at these six locations under Alternative 2 would be similar to the No Action Alternative—with all months, of all year types, changing less than, or equal to, 1 percent.

Table 5-60. Changes in Salinity (EC) at Rock Slough Under Alternative 2 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (umhos/cm)												
Wet	569	538	520	586	588	533	455	392	280	278	338	575
Above Normal	783	870	741	596	543	524	402	416	289	282	362	563
Below Normal	579	551	565	663	529	427	409	419	307	346	467	696
Dry	695	727	748	756	510	426	384	378	306	414	647	735
Critical	909	997	1,043	977	627	487	418	417	423	539	749	887
Average All Years	685	706	693	696	560	484	417	400	312	359	495	674
Alternative 2 (umhos/cm)												
Wet	569	538	520	586	588	533	455	392	280	278	338	575
Above Normal	784	871	738	595	543	524	402	416	289	282	363	564
Below Normal	579	551	565	663	529	427	409	419	307	346	466	696
Dry	695	727	748	756	510	426	384	378	306	414	649	736
Critical	909	998	1,045	978	626	487	417	418	422	539	748	888
Average All Years	685	706	693	697	560	484	417	400	312	359	495	674
No Action Compared to Alternative 2 (umhos/cm)												
Wet	0	0	0	0	0	0	0	0	0	0	0	0
Above Normal	1	1	-3	-1	0	0	0	0	0	0	1	1
Below Normal	0	0	0	0	0	0	0	0	0	0	-1	0
Dry	0	0	0	0	0	0	0	0	0	0	2	1
Critical	0	1	2	1	-1	0	-1	1	-1	0	-1	1
Average All Years	0	0	0	1	0	0	0	0	0	0	0	0
No Action Compared to Alternative 2 (%)												
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Below Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Critical	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Key:
% = percent
EC = electrical conductivity
umhos/cm = micromhos per centimeter

Table 5-61. Changes in Salinity (EC) on Sacramento River at Emmaton Under Alternative 2 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (umhos/cm)												
Wet	1,323	774	312	214	184	183	187	192	276	297	838	328
Above Normal	2,713	1,735	720	271	193	184	193	209	384	347	855	557
Below Normal	1,386	1,079	869	463	248	223	244	292	551	501	1,113	2,228
Dry	2,242	1,822	1,298	599	286	222	248	327	607	986	2,119	2,866
Critical	3,430	3,346	2,163	1,017	437	358	436	815	1,503	2,134	3,007	3,860
Average All Years	2,084	1,599	963	468	256	224	247	332	591	769	1,508	1,755
Alternative 2 (umhos/cm)												
Wet	1,323	774	312	214	184	183	187	192	276	297	838	328
Above Normal	2,721	1,717	720	271	193	184	193	209	384	347	854	558
Below Normal	1,386	1,078	869	463	248	223	244	292	551	500	1,113	2,229
Dry	2,241	1,818	1,298	599	286	222	248	327	607	985	2,120	2,867
Critical	3,438	3,344	2,163	1,016	436	358	436	815	1,498	2,143	3,012	3,874
Average All Years	2,087	1,595	963	468	256	224	247	332	590	770	1,508	1,757
No Action Compared to Alternative 2 (umhos/cm)												
Wet	0	0	0	0	0	0	0	0	0	0	0	0
Above Normal	8	-18	0	0	0	0	0	0	0	0	-1	1
Below Normal	0	-1	0	0	0	0	0	0	0	-1	0	1
Dry	-1	-4	0	0	0	0	0	0	0	-1	1	1
Critical	8	-2	0	-1	-1	0	0	0	-5	9	5	14
Average All Years	3	-4	0	0	0	0	0	0	-1	1	0	2
No Action Compared to Alternative 2 (%)												
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	0%	-1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Below Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Critical	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Key:
% = percent
EC = electrical conductivity
umhos/cm = micromhos per centimeter

Table 5-62. Changes in Salinity (EC) on San Joaquin River at Jersey Point Under Alternative 2 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (umhos/cm)												
Wet	1,114	958	503	284	238	221	222	214	239	345	1,063	936
Above Normal	2,148	1,759	1,088	465	252	218	229	239	305	468	1,178	1,007
Below Normal	1,107	1,151	1,168	692	325	243	248	276	378	816	1,458	2,431
Dry	1,693	1,689	1,590	952	389	255	248	288	416	1,298	1,704	2,466
Critical	2,459	2,509	2,134	1,309	536	330	352	542	904	1,613	2,115	2,718
Average All Years	1,615	1,516	1,189	680	332	248	252	292	409	846	1,445	1,782
Alternative 2 (umhos/cm)												
Wet	1,115	957	503	284	238	221	222	214	239	345	1,063	936
Above Normal	2,148	1,741	1,086	465	252	218	229	239	305	468	1,180	1,008
Below Normal	1,107	1,151	1,168	692	325	243	248	276	378	816	1,458	2,432
Dry	1,693	1,689	1,591	952	388	255	248	288	416	1,300	1,705	2,467
Critical	2,463	2,514	2,136	1,307	535	330	352	542	906	1,610	2,117	2,718
Average All Years	1,616	1,514	1,189	680	332	248	252	292	409	846	1,445	1,782
No Action Compared to Alternative 2 (umhos/cm)												
Wet	1	-1	0	0	0	0	0	0	0	0	0	0
Above Normal	0	-18	-2	0	0	0	0	0	0	0	2	1
Below Normal	0	0	0	0	0	0	0	0	0	0	0	1
Dry	0	0	1	0	-1	0	0	0	0	2	1	1
Critical	4	5	2	-2	-1	0	0	0	2	-3	2	0
Average All Years	1	-2	0	0	0	0	0	0	0	0	0	0
No Action Compared to Alternative 2 (%)												
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	0%	-1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Below Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Critical	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Key:
% = percent
EC = electrical conductivity
umhos/cm = micromhos per centimeter

Table 5-63. Changes in Salinity (EC) on Sacramento River at Collinsville Under Alternative 2 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (umhos/cm)												
Wet	4,127	2,900	1,039	403	200	198	218	291	916	1,422	3,821	1,226
Above Normal	7,539	5,358	2,987	778	261	220	249	421	1,716	1,869	3,925	2,880
Below Normal	4,255	3,826	3,579	2,046	752	599	725	1,154	2,518	2,746	4,747	7,305
Dry	6,541	6,049	5,129	2,772	956	540	778	1,409	2,765	4,487	6,762	8,422
Critical	9,144	9,192	7,249	4,254	1,845	1,454	2,011	3,327	5,037	6,844	8,416	9,739
Average All Years	6,008	5,103	3,595	1,824	709	523	690	1,145	2,312	3,212	5,351	5,305
Alternative 2 (umhos/cm)												
Wet	4,128	2,895	1,038	403	200	198	218	291	916	1,422	3,820	1,226
Above Normal	7,548	5,313	2,986	777	261	220	249	421	1,715	1,869	3,923	2,879
Below Normal	4,255	3,826	3,579	2,047	752	599	725	1,154	2,518	2,745	4,746	7,306
Dry	6,540	6,044	5,128	2,771	955	540	778	1,409	2,766	4,485	6,763	8,424
Critical	9,155	9,194	7,248	4,250	1,843	1,455	2,012	3,328	5,032	6,852	8,426	9,749
Average All Years	6,011	5,093	3,594	1,823	708	523	690	1,145	2,311	3,212	5,353	5,307
No Action Compared to Alternative 2 (umhos/cm)												
Wet	1	-5	-1	0	0	0	0	0	0	0	-1	0
Above Normal	9	-45	-1	-1	0	0	0	0	-1	0	-2	-1
Below Normal	0	0	0	1	0	0	0	0	0	-1	-1	1
Dry	-1	-5	-1	-1	-1	0	0	0	1	-2	1	2
Critical	11	2	-1	-4	-2	1	1	1	-5	8	10	10
Average All Years	3	-10	-1	-1	-1	0	0	0	-1	0	2	2
No Action Compared to Alternative 2 (%)												
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	0%	-1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Below Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Critical	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Key:
% = percent
EC = electrical conductivity
umhos/cm = micromhos per centimeter

Table 5-64. Changes in Salinity (EC) at Banks Pumping Plant Under Alternative 2 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (umhos/cm)												
Wet	473	443	428	470	389	329	250	276	301	281	307	458
Above Normal	667	662	571	591	517	407	331	362	324	274	317	414
Below Normal	478	460	494	584	558	476	380	424	356	306	392	615
Dry	570	588	600	663	592	549	452	453	352	364	515	632
Critical	742	780	788	768	708	690	569	535	452	490	605	740
Average All Years	568	565	554	595	528	467	376	391	347	334	414	556
Alternative 2 (umhos/cm)												
Wet	473	442	427	470	389	329	250	276	301	281	307	458
Above Normal	668	660	570	591	517	407	331	362	324	274	317	415
Below Normal	478	460	494	584	558	476	380	424	356	306	392	615
Dry	570	588	600	664	592	549	452	453	352	364	515	633
Critical	743	782	790	768	708	689	569	535	451	489	604	739
Average All Years	568	564	554	595	528	467	376	391	346	334	414	556
No Action Compared to Alternative 2 (umhos/cm)												
Wet	0	-1	-1	0	0	0	0	0	0	0	0	0
Above Normal	1	-2	-1	0	0	0	0	0	0	0	0	1
Below Normal	0	0	0	0	0	0	0	0	0	0	0	0
Dry	0	0	0	1	0	0	0	0	0	0	0	1
Critical	1	2	2	0	0	-1	0	0	-1	-1	-1	-1
Average All Years	0	-1	0	0	0	0	0	0	-1	0	0	0
No Action Compared to Alternative 2 (%)												
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Below Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Critical	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Key:
% = percent
EC = electrical conductivity
umhos/cm = micromhos per centimeter

Table 5-65. Changes in Salinity (EC) at Jones Pumping Plant Under Alternative 2 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (umhos/cm)												
Wet	473	455	496	517	406	336	265	288	345	345	331	449
Above Normal	624	627	608	631	572	449	353	375	373	332	343	426
Below Normal	478	469	564	627	618	531	405	433	392	334	407	581
Dry	550	570	633	687	664	619	483	480	388	383	512	602
Critical	684	721	761	774	784	787	621	569	472	492	588	696
Average All Years	547	551	595	629	579	515	403	409	385	372	425	536
Alternative 2 (umhos/cm)												
Wet	473	454	496	517	406	336	265	288	345	345	331	449
Above Normal	624	626	608	630	572	449	353	375	373	332	343	426
Below Normal	478	469	564	627	618	531	405	433	392	334	407	581
Dry	550	570	633	688	664	619	483	480	388	383	513	602
Critical	685	722	764	774	782	786	621	569	470	491	587	695
Average All Years	547	551	595	629	579	515	403	409	385	372	425	536
No Action Compared to Alternative 2 (umhos/cm)												
Wet	0	-1	0	0	0	0	0	0	0	0	0	0
Above Normal	0	-1	0	-1	0	0	0	0	0	0	0	0
Below Normal	0	0	0	0	0	0	0	0	0	0	0	0
Dry	0	0	0	1	0	0	0	0	0	0	1	0
Critical	1	1	3	0	-2	-1	0	0	-2	-1	-1	-1
Average All Years	0	0	0	0	0	0	0	0	0	0	0	0
No Action Compared to Alternative 2 (%)												
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Below Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Critical	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Key:
% = percent
EC = electrical conductivity
umhos/cm = micromhos per centimeter

X2 Position X2 positions are summarized in Table 5-66. X2 positions in Alternative 2 would be similar to the No Action Alternative—with all months, of all year types, changing less than, or equal to, 1 percent.

Table 5-66. Changes in X2 Positions Under Alternative 2 as Compared to the No Action Alternative, by Sacramento Water Year Type

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action (km)												
Wet	80.6	76.8	63.7	54.8	51.2	53.1	55.1	58.4	67.3	74.9	82.8	73.9
Above Normal	86.8	82.6	75.2	60.9	54.9	55.3	59.1	65.2	75.3	77.8	83.1	74.7
Below Normal	80.4	80.3	80.4	74.6	64.3	66.9	69.0	72.9	79.1	81.1	85.1	89.4
Dry	85.7	85.5	84.5	77.7	67.7	65.4	68.8	74.5	80.1	84.5	87.6	90.6
Critical	90.5	90.7	88.3	82.1	75.3	74.6	77.7	82.3	85.2	87.9	90.3	92.2
Average All Years	84.2	82.4	76.4	68.0	61.1	61.4	64.2	68.9	75.9	80.4	85.4	82.9
Alternative 2 (km)												
Wet	80.6	76.8	63.7	54.8	51.2	53.1	55.1	58.4	67.3	74.9	82.8	73.9
Above Normal	86.9	82.6	75.2	60.9	54.9	55.3	59.1	65.2	75.3	77.8	83.1	74.7
Below Normal	80.4	80.3	80.4	74.6	64.3	66.9	69.0	72.9	79.1	81.1	85.1	89.4
Dry	85.7	85.5	84.5	77.7	67.7	65.4	68.8	74.5	80.1	84.5	87.6	90.6
Critical	90.5	90.7	88.3	82.1	75.3	74.6	77.7	82.3	85.2	87.9	90.3	92.2
Average All Years	84.2	82.3	76.4	68.0	61.1	61.4	64.2	68.9	75.9	80.4	85.4	82.9
No Action Compared to Alternative 2 (km)												
Wet	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Above Normal	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Below Normal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Critical	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Average All Years	0.0	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
No Action Compared to Alternative 2 (%)												
Wet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Below Normal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Critical	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Average All Years	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Key:
% = percent
km = kilometer

Summary of Environmental Consequences

Table 5-67 presents the results of the environmental consequences analysis for implementing the action alternatives compared to the No Action Alternative.

It should be noted that since concentrations of water quality constituents not covered in the impact analysis would be managed through regulatory processes by 2030, it is assumed that concentrations of these constituents would be similar under the No Action Alternative and the action alternatives.

Environmental effects associated with changes in water temperatures are related to impacts on biological resources (as described in Chapter 7, "Biological Resources – Fisheries"). Therefore, the potential impacts of the action alternatives related to changes in water temperature, including changes resulting from including reasonably and foreseeable actions, are presented in Chapter 7.

Table 5-67. Comparison of Action Alternatives to No Action Alternative

Alternative	Potential Change	Consideration for Mitigation Measures
Alternative 1	*Trinity River: Lewiston Dam to the Klamath River*	
	Water temperatures on the Trinity River, below Lewiston Dam, would be similar to the No Action Alternative, with most months of the year changing 1% or less. Exceptions are increases of 2% in October and December of normal years, increases of 5% in July in critically dry years, and reductions of 2% and 3% in August and September respectively. Days of non-compliance with temperature objectives changed by 1% or less in the spring compared to the No Action Alternative.	Environmental effects associated with changes in water temperature may affect fish habitat and are related to impacts on fisheries (as described in Chapter 7, "Biological Resources – Fisheries"). Mitigation measures, if needed, related to environmental changes caused by changes in surface water quality conditions are presented in Chapter 7.
	Water temperatures on the Trinity River at Douglas City would be similar to the No Action Alternative, with most months of the year changing 1% or less. Exceptions are in normal years, with reductions of 2% in September and 2% increases in October, and in critically dry years, with increases of 4% in July and reductions of 2% and 3% in August and September. Days of non-compliance with temperature objectives changed by 1% or less in the fall and spring compared to the No Action Alternative.	
	Water temperatures on the Trinity River, below the North Fork Trinity River, would be similar to the No Action Alternative, with most months of the year changing 1% or less. Exceptions are in July of critically dry years (2% increase), August of normal and critically dry years (3% decrease), and September of critically dry, dry, and normal years, with reductions of 2% to 6%. Days of non-compliance with temperature objectives changed by 1% or less in the fall and spring compared to the No Action Alternative.	
	Water temperatures on the Trinity River, below the South Fork Trinity River, would be similar to the No Action Alternative, with most months of the year changing 1% or less. Exceptions are in critically dry, dry, and normal years, in August (reductions of 2% to 4%) and in September (reductions of 5% to 9%). Days of non-compliance with temperature objectives changed by 1% or less in the spring compared to the No Action Alternative.	
	Water temperatures on the Trinity River near Weitchpec would be similar to the No Action Alternative, with most months of the year changing 1% or less. Exceptions are in critically dry, dry, and normal years, in August (reductions of 2% to 4% change) and in September (reductions of 5% to 9%). Days of non-compliance with temperature objectives changed by 1% or less in the spring compared to the No Action Alternative.	
	Nutrient concentrations, organic matter concentrations, and DO in the Trinity River would be similar to the No Action Alternative during all months and year types.	None needed

Table 5-67. Comparison of Action Alternatives to No Action Alternative (contd.)

Alternative	Potential Change	Consideration for Mitigation Measures
Alternative 1 (contd.)	*Klamath River: Below Trinity River*	None needed
	Water temperatures on the lower Klamath River would be similar to the No Action Alternative, with most months of the year changing 1% or less. Exceptions are in critically dry and normal years, in August (reductions of 2%) and in September (reductions of 3% to 6%).	
	Nutrient concentrations, organic matter concentrations, and DO in the lower Klamath River would be similar to the No Action Alternative during most months and year types. Lower nutrient and organic matter concentrations are anticipated in August and September during flow augmentation actions, particularly in drier years.	
	Sacramento River Below Keswick Dam	None needed
	Water temperatures on the Sacramento River below Clear Creek, and at Balls Ferry, Jellys Ferry, and Bend Bridge, would be similar to the No Action Alternative with all months of all year types changing less than, or equal to, 1%.	
	Clear Creek Below Whiskeytown Dam	
	Water temperatures on Clear Creek at Igo would be similar to the No Action Alternative with all months of all year types changing less than, or equal to, 1%.	
	Feather River Below Thermalito/Oroville Dam	
	Water temperatures on the Feather River were not modelled, but because Oroville storage and releases change by 1% or less in Alternative 1 (as compared to the No Action Alternative), changes in downstream water temperatures are assumed to be similar.	
	American River Below Nimbus Dam	
	Water temperatures on the American River were not modelled, but because Folsom storage and releases change by 1% or less in Alternative 1 (as compared to the No Action Alternative), changes in downstream water temperatures are assumed to be similar.	
	Delta Salinity	None needed
	Salinities in the Delta at Rock Slough, Emmaton, Jersey Point, Collinsville, and at Banks and Jones Pumping Plants would be similar to the No Action Alternative with all months of all year types changing less than, or equal to, 1%.	
	X2 Position	None Needed
	X2 Position would be similar to the No Action Alternative with all months of all year types changing less than, or equal to, 1%.	

Table 5-67. Comparison of Action Alternatives to No Action Alternative (contd.)

Alternative	Potential Change	Consideration for Mitigation Measures
Alternative 2	*Trinity River: Lewiston Dam to the Klamath River* Water temperatures on the Trinity River, below Lewiston Dam, would be similar to the No Action Alternative, with most months of the year changing 1% or less. Exceptions are increases of 2% in December of normal years, and in critically dry years, reductions of 2% in August and 3% in September. Days of non-compliance with temperature objectives changed by 1% or less in the spring compared to the No Action Alternative. Water temperatures on the Trinity River at Douglas City would be similar to the No Action Alternative, with most months of the year changing 1% or less. Exceptions are in normal years, with reductions of 2% in September, and in critically dry years, with increases of 2% in June and reductions of 2% and 3% in August and September. Days of non-compliance with temperature objectives changed by 1% or less in the fall and spring compared to the No Action Alternative. Water temperatures on the Trinity River, below the North Fork Trinity River, would be similar to the No Action Alternative, with most months of the year changing 1% or less. Exceptions are in June of critically dry years (3% increase), August of normal, dry and critically dry years (reductions of 2% to 3%), and September of critically dry, dry, and normal years, with reductions of 3% to 6%. Days of non-compliance with temperature objectives changed by 1% or less in the fall and spring compared to the No Action Alternative. Water temperatures on the Trinity River, below the South Fork Trinity River, would be similar to the No Action Alternative, with most months of the year changing 1% or less. Exceptions are in June of critically dry years (2% increase), and in critically dry, dry, and normal years, in August (reductions of 2% to 4%) and in September (reductions of 5% to 9%). The percent of days out of compliance with spring temperature objectives increased by 2% compared to the No Action Alternative. Water temperatures on the Trinity River near Weitchpec would be similar to the No Action Alternative, with most months of the year changing 1% or less. Exceptions are in June of critically dry years (2%), and in critically, dry, and normal years in August (reductions of 2% to 4%) and in September (reductions of 5% to 9%). The percent of days out of compliance with spring temperature objectives increased by 2% compared to the No Action Alternative.	Environmental effects associated with changes in water temperature may affect fish habitat and are related to impacts on fisheries (as described in Chapter 7, “Biological Resources – Fisheries”). Mitigation measures, if needed, related to environmental changes caused by changes in surface water quality conditions are presented in Chapter 7.
	Nutrient concentrations, organic matter concentrations, and DO in the Trinity River would be similar to the No Action Alternative during all months and year types.	None needed

Table 5-67. Comparison of Action Alternatives to No Action Alternative (contd.)

Alternative	Potential Change	Consideration for Mitigation Measures
Alternative 2 (contd.)	*Klamath River: Below Trinity River*	None needed
	Water temperatures on the Klamath River, below the Trinity River, would be similar to the No Action Alternative, with most months of the year changing 1% or less. Exceptions are in critically dry and normal years in August (reductions of 2%) and in critically dry, dry, and normal years in September (reductions of 3% to 6%).	
	Nutrient concentrations, organic matter concentrations, and DO in the lower Klamath River would be similar to the No Action Alternative during most months and year types. Lower nutrient and organic matter concentrations are anticipated in August and September during flow augmentation actions, particularly in drier years.	
	Sacramento River Below Keswick Dam	None needed
	Water temperatures on the Sacramento River below Clear Creek, and at Balls Ferry, Jellys Ferry, and Bend Bridge, would be similar to the No Action Alternative with all months of all year types changing less than, or equal to, 1%.	
	Clear Creek Below Whiskeytown Dam	
	Water temperatures on Clear Creek at Igo would be similar to the No Action Alternative with all months of all year types changing less than, or equal to, 1%.	
	Feather River Below Thermalito/Oroville Dam	
	Water temperatures on the Feather River were not modelled, but because Oroville storage and releases change by 1% or less in Alternative 2 (as compared to the No Action Alternative), changes in downstream water temperatures are assumed to be similar.	
	American River Below Nimbus Dam	
	Water temperatures on the American River were not modelled, but because Folsom storage and releases change by 1% or less in Alternative 2 (as compared to the No Action Alternative), changes in downstream water temperatures are assumed to be similar.	
	Delta Salinity	None needed
	Salinities in the Delta at Rock Slough, Emmaton, Jersey Point, Collinsville, and at Banks and Jones Pumping Plants would be similar to the No Action Alternative with all months of all year types changing less than, or equal to, 1%.	
	X2 Position	None needed
	X2 Position would be similar to the No Action Alternative with all months of all year types changing less than, or equal to, 1%.	

Key:
% = percent
DO = dissolved oxygen

Potential Mitigation Measures

Mitigation measures are identified, as appropriate, to avoid, minimize, rectify, reduce, eliminate, or compensate for adverse environmental effects of action alternatives, as compared to the No Action Alternative.

There are no mitigation measures proposed for direct environmental impacts from changes to water temperature due to CVP and SWP operational changes. Impacts of these changes on other resource areas (i.e., fisheries) and potential mitigation measures, if required, are included in the chapters dealing with the specific resource area.

Cumulative Effects Analysis

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 of the action alternatives for water quality is summarized in Table 5-68. The methodology for this cumulative effects analysis is described in the Cumulative Effects Technical Appendix.

Table 5-68. Summary of Cumulative Effects on Water Quality of Action Alternatives as Compared to the No Action Alternative

Scenarios	Cumulative Effects of Actions
No Action Alternative with Associated Cumulative Effects Actions in Year 2030	*Conditions and Actions included in Quantitative Analyses* *(Conditions and actions incorporated into No Action Alternative modeling)* Climate change is anticipated to increase ambient air temperatures, increasing water temperatures in both regulated and unregulated rivers and streams. Climate change is also anticipated to shift winter precipitation from snow to rain, which will lead to larger runoff events in the winter and less snowmelt in the spring. Reservoir storage in turn will be reduced during summer months because of the need to maintain flood capacity in the winter versus being able to store more predictable snowmelt-driven flows in the spring. Lower reservoir storages, combined with increases in ambient air temperatures, are expected to cause further increases in water temperatures downstream of reservoirs, compared to recent historical conditions. Sea-level rise is also likely to cause increased salinities in the Delta—and more eastward locations for X2—compared to recent historical conditions. *Additional Identified Actions* *(Additional projects identified in Cumulative Effects Technical Appendix)* Additional reasonably foreseeable actions related to improved water quality and habitat conditions (e.g., FERC relicensing projects and Klamath River Main-Stem Dam Removal), could influence the timing of stream flows and associated surface water temperatures and other water quality parameters.
Alternative 1 with Associated Cumulative Effects Actions in Year 2030	*Alternative 1 with Conditions and Actions included in Quantitative Analyses* Implementation of Alternative 1 would result in similar water temperatures in most months and year types in both Klamath and Sacramento basin rivers as compared to the No Action Alternative. Exceptions include improvements (decreases) in water temperatures in the Klamath River below the Trinity River confluence in critically dry and normal years during September. Implementation of Alternative 1 would result in similar changes to water quality conditions for nutrients, DO, and organic matter in Klamath Basin rivers as compared to the No Action Alternative. Implementation of Alternative 1 would result in similar Delta water quality in all months and year types as compared to the No Action Alternative.

Table 5-68. Summary of Cumulative Effects on Water Quality of Action Alternatives as Compared to the No Action Alternative

Scenarios	Cumulative Effects of Actions
Alternative 1 with Associated Cumulative Effects Actions in Year 2030 (contd.)	*Alternative 1 with Additional Identified Actions* Implementation of Alternative 1 with the additional reasonably foreseeable actions would result in similar water temperatures in both Klamath and Sacramento basin rivers as compared to the No Action Alternative with the additional reasonably foreseeable actions. Exceptions include improvements (decreases) in water temperatures in the Klamath River below the Trinity River confluence in critically dry and normal years during September. Alternative 1 with the additional reasonably foreseeable action would result in beneficial effects to water quality, and therefore cumulative effects to water quality are not anticipated. Implementation of Alternative 1 with the additional reasonably foreseeable actions would result in similar Delta water quality in all months and year types as compared to the No Action Alternative with the additional reasonably foreseeable actions.
Alternative 2 with Associated Cumulative Effects Actions in Year 2030	*Alternative 2 with Conditions and Actions included in Quantitative Analyses* Implementation of Alternative 2 would result in similar water temperatures in most months and year types in both Klamath and Sacramento basin rivers as compared to the No Action Alternative. Exceptions include improvements (decreases) in water temperatures in the Klamath River below the Trinity River confluence in critically dry and normal years during September. Implementation of Alternative 2 would result in similar changes to water quality conditions for nutrients, DO, and organic matter in Klamath Basin rivers as compared to the No Action Alternative. Implementation of Alternative 2 would result in similar Delta water quality in all months and year types as compared to the No Action Alternative. *Alternative 2 with Additional Identified Actions* Implementation of Alternative 2 with the additional reasonably foreseeable actions would result in similar water temperatures in most months and year types in both Klamath and Sacramento basin rivers as compared to the No Action Alternative with the additional reasonably foreseeable actions. Exceptions include improvements (decreases) in water temperatures in the Klamath River below the Trinity River confluence in critically dry and normal years during September. Implementation of Alternative 2 with the additional reasonably foreseeable actions would result in similar changes to water quality conditions for nutrients, DO, and organic matter in Klamath Basin rivers as the No Action Alternative with the additional reasonably foreseeable actions. Implementation of Alternative 2 with the additional reasonably foreseeable actions would result in similar Delta water quality in all months and year types as compared to the No Action Alternative with the additional reasonably foreseeable actions.

Key:
DO = Dissolved Oxygen
FERC = Federal Energy Regulatory Commission

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Chapter 6
Groundwater Resources/Groundwater Quality

Introduction

This chapter describes the groundwater resources/groundwater quality in the study area and the potential changes that could occur as a result of implementing the alternatives evaluated in this Environmental Impact Statement (EIS). Implementation of the alternatives could affect groundwater resources through operational changes at Trinity Dam and other Central Valley Project (CVP) facilities.

Affected Environment

This section describes groundwater resources that could potentially be affected by the implementation of the alternatives considered in this EIS. Groundwater is present throughout the study area. However, the groundwater resources that could be directly or indirectly affected through implementation of the alternatives analyzed in this EIS are located in groundwater basins. These resources are available to users of CVP surface water supplies, who also use groundwater to meet their water demands not met by surface water deliveries. In addition, there are areas along the rivers downstream of CVP reservoirs that also use and rely on groundwater supplies. Therefore, the following description of the affected environment is limited to these areas, and it does not include groundwater basins or subbasins that are not directly or indirectly affected by changes in CVP operations.

Changes in groundwater resources resulting from changes in CVP operations may occur in the Lower Klamath and Trinity River Region, and the Central Valley and Bay-Delta Region. The Lower Klamath and Trinity River Region includes the area in Trinity County along the Trinity River, from Trinity Lake to the river's confluence with the Klamath River; and in Humboldt and Del Norte Counties along the Klamath River, from its confluence with the Trinity River to the Pacific Ocean. The Central Valley and Bay-Delta Region extends from above Shasta Lake, south to the Tehachapi Mountains, and includes the Sacramento Valley, San Joaquin Valley, and the Sacramento-San Joaquin River Delta (Delta).

Overview of California Groundwater Resources

As described in Chapter 4, "Surface Water Supply and Management," groundwater is a vital resource in California. Groundwater supplied about 37 percent of the State's average agricultural, municipal, and industrial water needs between 1998 and 2010, and 40 percent or more during dry and critical water years in that period (DWR 2013). About 20 percent of the nation's groundwater demand is supplied from Central Valley aquifers, making it the second-most-pumped aquifer system in the United States (USGS 2009). The three Central Valley

hydrologic regions (Tulare Lake, San Joaquin River, and Sacramento River) account for about 75 percent of California's average annual groundwater use (DWR 2013).

A delineation of the groundwater systems throughout the State has been conducted by the California Department of Water Resources (DWR), with the results presented in Bulletin 118-03 (DWR 2003). Specific groundwater studies have been conducted by regional water agencies or the U.S. Geological Survey (USGS), to update the statewide survey conducted by DWR in 1980 (USGS 2000, 2006, 2008, 2009, 2012). The results of some of those studies are referenced in the following subsections of this chapter.

The overdraft of groundwater basins is of serious concern and scrutiny in California, and is one of the factors for the passage of the Sustainable Groundwater Management Act (SGMA). A comprehensive assessment of overdraft in all of the State's groundwater basins has not been conducted since Bulletin 118-80 was published in 1980, but overdraft is estimated between 1 to 2 million acre-feet annually (DWR 2003). In DWR's Bulletin 118-80 (DWR 1980), an assessment of critically overdrafted basins was conducted, and this assessment identified 11 basins in critical condition of overdraft. Based on SGMA requirements, the State identified basins subject to critical conditions of overdraft in 2015, and provided local agencies and interested parties with the opportunity to provide comments on the draft list. These comments were evaluated by DWR against data submitted, and no revisions were made to the draft list. As described in the *Coordinated Long-Term Operation of the CVP and State Water Project* EIS (Reclamation 2015), the final list will also be included in Bulletin 118, Interim Update 2017, which is expected to be published in late 2016. The update will contain three basins in the EIS study area that are considered in critical conditions of overdraft (DWR 2015). The basins are:

- Merced: Subsidence in El Nido area of 0.6 to 1.0 ft/year
- Delta-Mendota: Significant, on-going and irreversible subsidence
- Westside: Significant, on-going and irreversible subsidence

Lower Klamath and Trinity River Region

The Lower Klamath and Trinity River Region includes the area along the Trinity River from Trinity Lake to the confluence with the Klamath River, and the lower Klamath River includes the area along the Klamath River from its confluence with the Trinity River to the Pacific Ocean. These two basins are the Hoopa Valley and Lower Klamath River Valley groundwater basins (DWR 2003).

Most usable groundwater in the Lower Klamath and Trinity River Region occurs in widely scattered alluvium-filled valleys, such as those immediately adjacent to the Trinity River. These valleys contain only small quantities of recoverable groundwater, and, therefore, are not considered a major source. A number of shallow wells adjacent to the river provide water for domestic purposes (Reclamation et al. 2006; NCRWQCB et al. 2009). Groundwater present in these alluvial valleys is in close hydraulic connection with the Trinity River and its tributaries. Both groundwater discharge to surface streams, as well as leakage of stream flow to underlying aquifers, are expected to occur at various locations.

Bulletin 118-03 (DWR 2003, DWR 2004a, 2004b) identified only two groundwater basins underlying the Lower Klamath and Trinity River Region, which are the Hoopa Valley and Lower Klamath River Valley groundwater basins. These groundwater basins are small, isolated, valley-fill aquifers that provide a very limited quantity of groundwater to satisfy local domestic, municipal, and agricultural needs. Groundwater pumped from these aquifer systems is used strictly for local supply.

Several communities use near-surface groundwater via intake galleries adjacent to the Trinity River (NCRWQCB et al. 2009). The systems using this include the Lewiston Community Services District, Lewiston Valley Water Company, and Lewiston Park Mutual Water Company.

Groundwater within the Hoopa Valley Indian Reservation occurs along alluvial terraces (Hoopa Valley Tribe 2008). The aquifers are approximately 10- to 80-feet deep, with some of the shallow wells being productive only during the winter and early spring months.

The Lower Klamath River Valley Groundwater Basin extends over 7,030 acres in Del Norte and Humboldt Counties, including areas along the lower Klamath River (Reclamation 2010). Groundwater along the lower Klamath River occurs in alluvial fans near the confluences of major tributaries and along terrace and floodplain deposits adjacent to the river (Yurok Tribe 2012). The depth of aquifers here ranges from 10 to 80 feet below ground surface and are used by some members of the community.

The Hoopa Valley and Lower Klamath River Valley groundwater basins were designated by the California Statewide Groundwater Elevation Monitoring Program program as very low and low priorities, respectively.

Groundwater quality is suitable for many beneficial uses in the region. In other locations, the groundwater can include naturally-occurring metals, such as manganese, cadmium, zinc, and barium (Hoopa Valley Tribe 2008). Groundwater quality issues include nitrate contamination (DWR 2013). Contamination of groundwater and surface water is suspected at several former and existing mill sites that historically used wood treatment chemicals. Discharges of pentachlorophenol, polychlorodibenzodioxins, and polychlorodibenzofurans—typically used in historical wood-treatment applications—are likely to have occurred due to poor containment practices. Additional investigation, sampling, monitoring, and enforcement actions have been limited by the insufficient resources that exist to address this historical toxic chemical problem (NCRWQCB 2005).

Central Valley and Bay-Delta Region

The Central Valley Region and Bay-Delta Region extends from above Lake Shasta, south to the Tehachapi Mountains, and includes the Sacramento Valley, San Joaquin Valley, and Sacramento-San Joaquin Rivers Delta (Delta).

Groundwater for the Central Valley and Bay-Delta Region is described in relation to the basins delineated in Bulletin 118-03 (DWR 2003). The overall area includes the Sacramento Valley Basin (which extends through the Sacramento Valley), and the San Joaquin Valley Groundwater Basin (including the Tulare Lake area), which extends through the San Joaquin Valley. The Delta area is located partially in the Sacramento Valley Basin and partially in the San Joaquin

Valley Groundwater Basin. There are separate descriptions for the Delta area because of the distinct characteristics as an estuary, at the confluence of the Sacramento and the San Joaquin rivers.

Sacramento Valley

The Sacramento Valley includes the Redding Groundwater Basin and the Sacramento Valley Groundwater Basin. In terms of size, the Sacramento Valley Groundwater Basin is one of the largest groundwater basins in the State, and extends from Redding in the north to the Delta in the south (USGS 2009). Approximately one-third of the Sacramento Valley's urban and agricultural water needs are met by groundwater (DWR 2003).

Overall, the Sacramento Groundwater Basin is approximately balanced with respect to annual recharge and pumping demand. However, there are several locations showing early signs of persistent drawdown, suggesting that the limits of sustainable groundwater use have been reached. Locations within this area include: Glenn County, areas near Chico in Butte County, northern Sacramento County, and portions of Yolo County.

Groundwater quality in the Sacramento Valley is generally good, as described below for individual basins. Several areas have localized high nitrate, total dissolved solids (TDS) or boron concentrations. High nitrate concentrations frequently occur due to residuals from agricultural activity (including livestock operations) or septic systems. High TDS, a measure of salinity, can be an indicator of brackish or connate water when it occurs in high concentrations. High boron concentration is usually associated with naturally-occurring deposits.

Overview of Groundwater Basins in the Sacramento Valley The Sacramento Valley includes the Redding Groundwater Basin and the Sacramento Valley Groundwater Basin. The Redding Groundwater Basin is situated in the extreme northern end of the Valley and is a separate, isolated groundwater basin, but due to similarities in geology and stratigraphy, it is included as part of the overall Sacramento Valley. It is bordered by the Coast Ranges on the west, and by the Cascade Range and Sierra Nevada mountains on the east.

The Sacramento Valley Groundwater Basin has been divided into 18 subbasins by DWR, based on groundwater characteristics, surface water features, and political boundaries (DWR 2003). From a hydrologic standpoint, these individual groundwater subbasins have a high degree of hydraulic connection, because rivers in the area do not always act as barriers to groundwater flow. Therefore, the Sacramento Valley Groundwater Basin functions primarily as a single laterally-extensive alluvial aquifer, rather than numerous discrete, smaller groundwater subbasins.

General Hydrogeology of the Sacramento Valley Presently, groundwater levels in the Valley are generally in equilibrium, with pumping matched by recharge from the various sources annually. Some locales show the early signs of persistent drawdown, especially in areas where water demands are met primarily, or are satisfied exclusively by groundwater. These areas include portions of the far west side of the Sacramento Valley in Glenn County, portions of Butte County near Chico, in portions of Yolo County, and in the northern Sacramento County area. Areas of prolonged and increasing drawdown may be indicative that the limits of sustainable groundwater use have been reached. Due to the drought that began in 2011, surface water

supplies have declined and new wells have been put into service. Between January and October 2014, over 100 water supply wells were drilled in both Shasta and Butte Counties (DWR 2014).

Land subsidence in the Sacramento Valley has resulted from inelastic deformation (non-recoverable changes) of fine-grained sediments related to groundwater withdrawal. Areas of subsidence from groundwater-level declines have been measured at several locations in the Sacramento Valley. Subsidence monitoring was established following several studies in the 1990s that indicated more than four feet of subsidence had occurred since 1954 in some areas, such as in Yolo County (Ikehara 1994). Initial data from the Yolo County extensometers (instruments used to quantify subsidence) indicated subsidence in the Zamora area. This reduction has subsequently been confirmed with a countywide global positioning system (GPS) network installed in 1999 and monitored in 2002 and 2005. Up to 0.4 feet of subsidence has occurred between 1999 and 2005 in that area (Frame Surveying and Mapping 2006). The Zamora area does not currently use CVP water supplies, but this area was designated as part of the CVP Sacramento Valley Irrigation Canals service area in the Reclamation Act of 1950, and as amended in the Reclamation Act of 1980 and Central Valley Project Improvement Act.

San Joaquin Valley

The San Joaquin Valley Groundwater Basin extends from the Delta in the north to the Tehachapi Mountains in the south. Groundwater is estimated to provide over 47 percent of the overall water supply in the San Joaquin Valley, including 70 percent of municipal uses and 43 percent of irrigation supplies from 2005 through 2010 (DWR 2013). Annual precipitation in the San Joaquin Valley averages between 5 to 18 inches. Due to the low amounts of average annual precipitation, limited surface water supply, and extensive agricultural water use, there are areas of significant overdraft that exist in the San Joaquin Valley Groundwater Basin. Eight subbasins in the San Joaquin Valley Groundwater Basin were identified to be in a state of critical overdraft: Chowchilla, Eastern San Joaquin, Madera, Kings, Kaweah, Tule, Tulare Lake, and Kern (DWR 1980). Three of these subbasins are on the eastern side of the San Joaquin River: Eastern San Joaquin, Chowchilla, and Madera. Recent studies have indicated that overdraft continues to exist in these subbasins (DWR 2013). By 1970, over 5,200 square miles of irrigable land had subsided at least one foot. The maximum subsidence, which occurred near Mendota, was recorded at almost 30 feet (9 meters) (Reclamation 2013). Due to the drought that started in 2011, surface water supplies have declined and new wells have been constructed. Between January and October 2014, more than 100 wells were drilled in both Kern and Kings Counties, almost 200 in Stanislaus County, almost 250 in Merced County, and over 350 in both Fresno and Tulare Counties (DWR 2014).

The elevation of the freshwater base in the western and central San Joaquin Valley ranges from 600 to 800 feet below mean sea level (WWD 2013). This area has experienced subsidence of up to 28 feet between 1926 and 1970 (USGS 2009) due to groundwater extraction that exceeds recharge. The water quality of the semi-perched aquifer on the western side of the San Joaquin Valley is impaired due to high salinity, selenium and boron concentrations. These constituents are from both naturally-occurring deposits in the Coast Ranges to the west and agricultural activities in the Valley. The chemicals become trapped in the soil matrix due to the low-permeability clay layers close to the surface. There are also localized areas with high concentrations of naturally-occurring arsenic or selenium.

Portions of the San Joaquin Valley Groundwater Basin in the Cosumnes, Tracy, and Eastern San Joaquin Subbasins were designated by the State Water Resources Control Board in 2000 as Hydrogeologically Vulnerable Areas and Groundwater Protection Areas, based on hydrogeologic permeability. These areas could be more vulnerable to groundwater-quality impairment if applied surface water—including recycled water—contains high concentrations of constituents that are of concern to the beneficial users of the groundwater (CVRWQCB 2014).

Delta

The Delta overlies the western portion of the area where the Sacramento River and San Joaquin River groundwater basins converge. This area also includes the Solano Subbasin and the South American Subbasin in the Sacramento Valley Groundwater Basin; the Tracy Subbasin, the Eastern San Joaquin Subbasin, and the Cosumnes Subbasin in the San Joaquin Valley Groundwater Basin; and the Suisun-Fairfield Valley Basin.

In some areas of the western and central Delta floodplain, the floodplain deposits contain organic material (peat) that ranges in thickness from zero to 150 feet. Below the surficial floodplain deposits, unconsolidated non-marine sediments occur, at depths of a few hundred feet near the Coast Range to nearly 3,000 feet near the eastern margin of the Sacramento Valley Groundwater Basin. These non-marine sediments form the major water-bearing formations in the Delta.

In general, shallow groundwater conditions and extensive groundwater-surface water interaction characterize the Delta. Spring runoff generated by melting snow in the Sierra Nevada increases flows in the Sacramento and San Joaquin Rivers and their tributaries, which causes groundwater levels near the rivers to rise. Because the Delta is a large floodplain, and the shallow groundwater is hydraulically connected to the surface water, changes in river stages affect groundwater levels and vice versa. Groundwater levels in the central Delta are very shallow, and land subsidence on several islands has resulted in groundwater levels close to the ground surface. Maintaining groundwater levels below crop rooting zones is critical for successful agriculture, especially for islands that lie below sea level. Many farmers rely on an intricate network of drainage ditches and pumps to maintain groundwater levels of approximately 3 to 6 feet below ground surface. The accumulated agricultural drainage is discharged into adjoining surface water bodies (USGS 2000). Without this drainage system, many of the islands would be subject to extremely high groundwater, bogs, or localized flooding.

Groundwater generally flows from the Sierra Nevada in the east toward the low-lying lands of the Delta to the west. However, a number of pumping depressions have reversed this trend, and groundwater inflow from the Delta toward these pumping areas has been observed, primarily in the Stockton area.

Subsidence in the Delta is well-documented and a major source of concern for farming operations. The oxidation of peat soils is the primary mechanism of subsidence in the Delta, and some areas are located below sea level. Another mechanism for subsidence is wind erosion. Certain areas in the Delta may continue to subside, 2 to 4 more feet, over the next 35 years (DWR 2013).

San Francisco Bay Area

The San Francisco Bay Area includes portions of Contra Costa, Alameda, Santa Clara, and San Benito Counties that are within the CVP service areas.

There are several groundwater basins in the San Francisco Bay Area, however, only some of the basins are within the CVP service areas evaluated in this EIS. The portions of the San Francisco Bay Area within the CVP service areas include the Pittsburg Plain, Clayton Valley, Ygnacio Valley, Arroyo Del Hambre Valley, San Ramon Valley, Livermore Valley, Castro Valley, and Santa Clara Valley Groundwater Basins within the San Francisco Bay Hydrologic Region; and Gilroy-Hollister Valley Groundwater Basin within the Central Coast Hydrologic Region.

Groundwater represents approximately 21 percent of the agricultural, municipal, and industrial water supplies in the San Francisco Bay Area (DWR 2013). Conjunctive use programs have been implemented by several agencies to optimize the use of groundwater and surface water resources.

The groundwater quality in the San Francisco Bay Area is generally suitable for most agricultural and municipal uses, but concerns exist about groundwater contamination from industrial and agricultural chemical spills, leaky underground and above-ground storage tanks, landfill leachate, and poorer-quality surface water bodies. There have been over 800 groundwater cleanup projects in the San Francisco Bay Area, with the majority of these resulting from leaky fuel tanks (DWR 2013). Portions of the San Francisco Bay Area Region shorelines include aquifers that are susceptible to seawater intrusion.

In the southern San Francisco Bay Area, groundwater and surface water are connected by in-stream and off-stream artificial recharge projects, in which surface water is delivered to water bodies that enable the infiltration (recharge) of water to underlying aquifers. Surface waters recharge aquifers in other regions of the San Francisco Bay Area along streambeds, especially in areas with depressed groundwater levels that have resulted from extensive groundwater pumping.

Impact Analysis

Potential Mechanisms for Change in Groundwater Resources

The impact analysis considers changes in groundwater resource conditions related to changes in CVP operations under the alternatives as compared to the No Action Alternative.

Changes to Groundwater Use and Groundwater Levels

Changes in availability of CVP water supplies could result in changes of groundwater use. For example, if CVP water deliveries are decreased, water users may increase the amount of groundwater withdrawals in response to the shortage in surface water deliveries, so as to make up the deficit in water supplies.

Historically, groundwater resources were the only water resources available to meet the demand for water supply in the Central Valley. The heavy use of groundwater has caused groundwater quality issues, drainage issues, groundwater overdraft, and land subsidence in the Central Valley (Reclamation 2015). Throughout many areas of the San Joaquin Valley, shallow groundwater is

characterized by high salinity. Use of this groundwater for irrigation deposited salts, along with agricultural chemicals (nutrients and fertilizers), into the upper soil layer. These constituents leached into the underlying shallow groundwater aquifers and caused them to be unsuitable for irrigation. Surface water delivered by the CVP provides irrigation water of higher quality than was available from local groundwater. The expanded use of surface water for irrigation has resulted in a reduction in groundwater overdraft of local groundwater basins (Reclamation 2015).

Generally, agricultural water users in the San Joaquin Valley prefer to use surface water for irrigation, when available, because the water quality is better than that of groundwater. However, when adequate surface water supplies are not available, the demand is met with the use of groundwater (USGS 2009).

SGMA mandates that most groundwater users in California must develop Groundwater Sustainability Plans (GSP) by 2020 or 2022, and meet the sustainable goal within 20 years of adoption of the GSP. The time frame of this EIS analysis is 2030. Therefore, this EIS analysis assumes that groundwater users have developed the GSPs within the requisite timeframe (by 2020 or 2022), and have begun to plan, design, and possibly construct alternative water supply facilities, or implement water conservation measures and management to achieve full compliance with SGMA by 2040 or 2042. However, this EIS analysis also assumes that the new facilities or conservation measures are not fully implemented by 2030. Therefore, reductions in groundwater use in accordance with the SGMA are not anticipated until after 2030 and are discussed under the section addressing *Cumulative Effects Analysis*.

Changes to groundwater use by users of CVP water supplies could result in changes in groundwater storage and groundwater levels within the study area. For example, if CVP water supplies are decreased and water users increase the amount of groundwater withdrawals, groundwater levels could decline. Changes in groundwater levels resulting in a lowering of the water table (declining groundwater levels) could result in a decrease in well yields.

As described in Chapter 4, “Surface Water Supply and Management,” the CalSim II model was used to estimate changes in the deliveries to CVP water users for each action alternative in this EIS. The change in delivery is then calculated by taking the difference between the alternative under consideration and the No Action Alternative for the respective year type, (e.g., wet, above normal, dry). Based on this approach, the decreases in the water delivered are not considerable enough to warrant a large increase in groundwater demand to meet the shortage of surface water supply created by these alternatives.

Changes in Land Subsidence

Extensive groundwater withdrawals from confined and unconfined aquifers increases the potential for land subsidence. In aquifers with clay and silt lenses, decreased groundwater levels can result in compaction of fine-grained deposits, which could lead to irreversible land subsidence. Subsidence could result in structural damage to roads, railroad tracks, pipelines and associated structures, drainage, buildings, and wells. Subsidence can also result in the permanent loss of groundwater storage potential within an aquifer system.

Land subsidence is a function of the rock (consolidated or unconsolidated) properties, the thickness of the water bearing units, and the change(s) in water level. Based on the premise

outlined in the section on *Changes to Groundwater Use and Groundwater Levels* above, there is no indication that groundwater levels will change enough under the alternatives reviewed here, as compared to the No Action Alternative, so that there will be any impact to subsidence.

Changes to Groundwater Quality

Changes to groundwater quality could occur in several ways under implementation of the alternatives as compared to the No Action Alternative. Reductions in groundwater levels could change groundwater flow directions or hydraulic gradients, potentially causing poorer-quality groundwater to migrate into areas with higher-quality groundwater—possibly at different rates—or cause intrusion of poor-water quality (e.g., from aquitards) as water levels decline.

Groundwater quality could also change due to changes in the availability of CVP water supplies used by agricultural water users. For example, if reductions in CVP water supplies result in an increased use of groundwater with higher salinity than CVP water supplies, shallow groundwater could become more saline and soil salinity could increase. In addition, the reduced availability of higher-quality surface water for use in recharge facilities may decrease the overall groundwater quality in those localized areas.

As outlined in the section on *Changes to Groundwater Use and Groundwater Levels*, there is no indication that groundwater levels will be impacted by the alternatives reviewed here as compared to the No Action Alternative.

Evaluation of Alternatives

The impact analysis in this EIS is based upon the comparison of the alternatives to the No Action Alternative in the year 2030. The results of CalSim II modelling were reviewed in order to consider the effects on groundwater demand and withdrawals created by decreased surface water deliveries. Chapter 4, “Surface Water Supply and Management,” discusses certain limitations of the CalSim II model, and that there may be minor fluctuations in the model of up to 5 percent, due to the assumptions and approaches. In addition, it notes that quantitative changes of 5 percent or less, between a specific alternative and the No Action Alternative, would be considered similar to conditions under the No Action Alternative, which is the same consideration utilized in this Evaluation of Alternatives.

No Action Alternative

Changes to Groundwater Use and Elevation Under the No Action Alternative, groundwater resources and groundwater quality would be comparable to the conditions described in the *Affected Environment* section of this chapter. Conditions in 2030 would be different than existing conditions, primarily due to expected variability in groundwater conditions, as well as climate change and sea-level rise, general plan development throughout California, and implementation of reasonable and foreseeable water resource management projects to provide water supplies. Climate change and sea-level rise are anticipated to reduce long-term average CVP water supply deliveries by 2030 as compared to recent historical long-term average deliveries. Climate change would also reduce groundwater supplies, due to reduced groundwater recharge potential and increased groundwater overdraft potential, as surface water supplies decline. However, in some locations, sustainable groundwater supplies could remain similar to recent historical conditions, or rise, due to implementation of groundwater management plans to reduce groundwater overdraft, including the completion of ongoing groundwater recharge and recovery programs.

For groundwater basins along the Trinity River and lower Klamath River, groundwater use and elevations are expected to remain similar to recent historical use and water levels. In the Central Valley and Delta, the combination of increased groundwater withdrawals—due to reductions in CVP and State Water Project (SWP) water deliveries—as compared to recent historical long-term deliveries and reduced groundwater recharge (due to climate change) could result in continued reductions in groundwater levels. These reductions could be in the same manner as recent declines of up to 10 feet in the Sacramento Valley, and more than 20 feet in the San Joaquin Valley (Reclamation 2015).

Under the No Action Alternative, groundwater banks and other management programs would continue to be implemented, and possibly expanded, including ongoing groundwater recharge efforts in the Eastern San Joaquin, Kings, Kaweah, and Kern Subbasins in the San Joaquin Valley Groundwater Basin. These programs could result in groundwater levels that are similar or higher comparative to recent groundwater conditions. If local agencies fully implement GSPs in accordance with the State SGMA prior to the regulatory deadline, groundwater levels could remain similar to recent conditions, or they could rise.

Changes to Land Subsidence Land subsidence due to groundwater withdrawals historically occurred in the Yolo Subbasin of the Sacramento Valley Groundwater Basin, the Delta-Mendota and Westside Subbasins of the San Joaquin Valley Groundwater Basin, and the Santa Clara Valley Groundwater Basin. Under the No Action Alternative, it is anticipated that increased groundwater withdrawals—due to reductions in CVP and SWP water supplies—and reduced groundwater recharge (due to climate change) could result in increased irreversible land subsidence in these areas.

Changes to Groundwater Quality In the Central Valley, there are localized areas of high salinity related to natural geologic formations and historic land uses; high naturally-occurring arsenic, calcium, iron, and manganese; and high levels of boron and phosphates related to historic land-use practices. High concentrations of nitrates, due to current anthropogenic sources and legacy sources, occur in many locations in the San Joaquin Valley Groundwater Basin, especially in the Eastern San Joaquin, Modesto, Merced, Kings, Kaweah, Tule, and Tulare Lake Subbasins. Under the No Action Alternative, it is anticipated that these conditions would continue to occur; and that groundwater quality could be further degraded due to reduction of groundwater elevation that can cause adjacent poorer-quality water to flow towards the groundwater withdrawals.

Proposed Action (Alternative 1)

Lower Klamath and Trinity River Region Groundwater conditions in the Lower Klamath and Trinity River Region are not directly related to CVP water supplies or operations.

Changes to Groundwater Use and Elevation Alternative 1 does not adversely affect water supplies in the Lower Klamath and Trinity River Region, and as such there are no impacts to groundwater use. Increased flows in the Lower Klamath and Trinity River Region may minimally increase the water surface elevation in the rivers during August and September. This could result in additional groundwater recharge, depending on the geographic location as well as duration. It will only have a minor effect on groundwater recharge, without creating any potentially-adverse impacts to groundwater elevation, as compared to the No Action Alternative.

Changes to Land Subsidence As discussed above, Alternative 1 will only have a minor effect on groundwater use, without creating any potentially-adverse impacts to groundwater elevation as compared to the No Action Alternative, and as such, will have no potentially-adverse impacts on subsidence for the area.

Changes to Groundwater Quality There are no adverse effects to water supplies in the Lower Klamath and Trinity River Region under Alternative 1, and there is the potential for minor additional recharge, netting no negative impacts to groundwater use and elevation under this alternative. With additional recharge, there may be a slight dilution effect in the aquifer(s), but it is not considered enough to create a large-scale change in water chemistry. The effect of this is that there are no adverse impacts on groundwater quality in the Lower Klamath and Trinity River Region under Alternative 1.

Central Valley and Bay-Delta Region

Sacramento Valley

Changes to Groundwater Use and Elevation CalSim II modelling showed that for most year types, CVP North-of-Delta (NOD) deliveries were similar for Alternative 1 compared to the No Action Alternative. Accordingly, groundwater use and elevation for most year types would be similar for Alternative 1 compared to the No Action Alternative. CVP NOD deliveries for all year types to CVP Sacramento River Settlement Contractors, CVP Refuge Level 2 Deliveries, and all of CVP municipal and industrial (M&I) for Alternative 1 were similar (less than 2 percent change), as compared to the No Action Alternative. In addition, long-term average deliveries (e.g., average of all year types) to CVP Agricultural Water Service Contractors NOD would be similar (1 percent decrease). However, Alternative 1 deliveries to the CVP Agricultural Water Service Contractors NOD in critical years would decrease by 10 percent in comparison to the No Action Alternative. A decrease in deliveries of 10 percent represents 2 thousand acre-feet (TAF), which, as a result of decreased supplies, would create additional demand that would vary geographically. It is not possible to speculate how water districts would manage water supplies in response to decreases in surface water supply, or how water users might react. Accordingly, Alternative 1 may potentially impact groundwater use and elevations during critical years in localized areas (e.g., service areas of water service contractors) compared to the No Action Alternative.

Changes to Land Subsidence As groundwater elevations under Alternative 1 would be similar to the No Action Alternative under all year types (except critical years), land subsidence for these year types would also be similar under Alternative 1 as compared to the No Action Alternative. As discussed above, it is not possible to speculate how CVP Agricultural Water Service Contractors NOD would respond to reduced surface-water deliveries. However, as there may be potentially-adverse impacts to groundwater levels under Alternative 1, compared to the No Action Alternative, there may be potentially-adverse impacts to land subsidence.

Changes to Groundwater Quality Groundwater quality for all year types would be similar under Alternative 1 as compared to the No Action Alternative. As groundwater elevations under Alternative 1 would be similar to the No Action Alternative under all year types (except critical years), water quality for these year types would also be similar under Alternative 1 as compared to the No Action Alternative. Alternative 1 may adversely impact groundwater levels in localized areas in comparison to the No Action Alternative, however groundwater quality

underlying these areas is generally of high quality. Accordingly, groundwater quality for critical years would be similar under Alternative 1 in comparison to the No Action Alternative.

San Joaquin Valley

Changes to Groundwater Use and Elevation CalSim II modelling showed that for most year types, CVP South-of-Delta (SOD) deliveries were similar for Alternative 1 compared to the No Action Alternative. Accordingly, groundwater use and elevation for most year types would be similar for Alternative 1 compared to the No Action Alternative. CVP SOD deliveries for all year types to CVP San Joaquin River Exchange Contractors, CVP Refuge Level 2 Deliveries, and all of CVP M&I for Alternative 1 were similar (less than 2 percent change), as compared to the No Action Alternative. In addition, long-term average deliveries (e.g., average of all year types) to CVP Agricultural Water Service Contractors SOD would be similar (1 percent change). However, Alternative 1 deliveries to the CVP Agricultural Water Service Contractors SOD in critical years would decrease by 7 percent, in comparison to the No Action Alternative. A decrease in deliveries of 7 percent represents 10 TAF, which, as a result of decreased supplies, would create additional demand that would vary geographically. Similarly, Alternative 1 deliveries are reduced during below normal and dry years by 10 TAF and 17 TAF, respectively. It is not possible to speculate how water districts would manage water supplies in response to decreases in surface water supply, or how water users might react. Accordingly, Alternative 1 may potentially impact groundwater use and elevations in localized areas (e.g., service areas of water service contractors) during some year types, compared to the No Action Alternative.

Changes to Land Subsidence Groundwater elevations under Alternative 1 would be similar to the No Action Alternative under all year types (except critical years), and land subsidence for these year types would also be similar under Alternative 1 as compared to the No Action Alternative. As discussed above, it is not possible to speculate how CVP Agricultural Water Service Contractors SOD would respond to reduced surface water deliveries. However, as there may be potentially-adverse impacts to groundwater levels under Alternative 1, compared to the No Action Alternative, there may be potentially-adverse impacts to land subsidence.

Changes to Groundwater Quality As discussed above, the average total CVP water deliveries do not impact the groundwater elevation, so there will be no impacts to water quality in the Sacramento Valley for almost all year types under Alternative 1. Similar impacts may occur for the CVP M&I SOD in critical year types, CVP Agricultural Water Service Contractors SOD in below normal year types, and CVP Agricultural Water Service Contractors SOD in dry year types, given that the groundwater use and elevation and will have similar impacts as compared to the No Action Alternative. Potentially-adverse impacts to water quality may be created for CVP Agricultural Water Service Contractors SOD in a critical year because the groundwater use and elevation may have potentially-adverse impacts.

Delta

Changes to Groundwater Use and Elevation CVP deliveries under Alternative 1 would be similar to those under the No Action Alternative. Consequently, groundwater use and elevation will be similar under Alternative 1 compared to the No Action Alternative.

Changes to Land Subsidence Under Alternative 1, based on CVP deliveries, groundwater levels and elevations would be similar to the No Action Alternative. Consequently, land subsidence under Alternative 1 will be similar to the No Action Alternative.

Changes to Groundwater Quality Under Alternative 1, based on CVP deliveries, groundwater levels and elevations would be similar to the No Action Alternative. Consequently, groundwater quality under Alternative 1 will be similar to the No Action Alternative.

San Francisco Bay Area

Changes to Groundwater Use and Elevation CVP deliveries under Alternative 1 would be similar to those under the No Action Alternative. Consequently, groundwater use and elevation will be similar under Alternative 1 compared to the No Action Alternative.

Changes to Land Subsidence Under Alternative 1, based on CVP deliveries, groundwater levels and elevations would be similar to the No Action Alternative. Consequently, land subsidence under Alternative 1 will be similar to the No Action Alternative.

Changes to Groundwater Quality Under Alternative 1, based on CVP deliveries, groundwater levels and elevations would be similar to the No Action Alternative. Consequently, groundwater quality under Alternative 1 will be similar to the No Action Alternative.

Trinity River Record of Decision Flow Rescheduling Alternative (Alternative 2)

Lower Klamath and Trinity River Region

Changes to Groundwater Use and Elevation Alternative 2 does not adversely affect water supplies in the Lower Klamath and Trinity River Region, and as such there are no impacts to groundwater use. River flows in the Lower Klamath and Trinity River Region may minimally increase the water surface elevation in the rivers during August and September. However, reduced flows may minimally decrease water-surface elevations in the rivers in May and June. These minimal changes in water-surface elevation would only have a minor effect on groundwater recharge, without creating any potentially-adverse impacts to groundwater elevation as compared to the No Action Alternative.

Changes to Land Subsidence As discussed above, Alternative 2 does not impact the Lower Klamath and Trinity River Region groundwater use or elevation, and as such, there are no impacts on subsidence for the area.

Changes to Groundwater Quality There are no affects to water supplies or related operations in the Lower Klamath and Trinity River Region under Alternative 2, so that there are no impacts to groundwater use and elevation under this alternative. The result is that there are no impacts on groundwater quality in the Lower Klamath and Trinity River Region under Alternative 2.

Central Valley and Bay-Delta Region

Sacramento Valley

Changes to Groundwater Use and Elevation CVP deliveries under Alternative 2 would be similar to those under the No Action Alternative. Consequently, groundwater use and elevation will be similar under Alternative 2 compared to the No Action Alternative.

Changes to Land Subsidence Under Alternative 2, based on CVP deliveries, groundwater levels and elevations would be similar to the No Action Alternative. Consequently, land subsidence under Alternative 2 will be similar to the No Action Alternative.

Changes to Groundwater Quality Alternative 2, based on CVP deliveries, groundwater levels and elevations would be similar to the No Action Alternative. Consequently, groundwater quality under Alternative 2 will be similar to the No Action Alternative.

San Joaquin Valley

Changes to Groundwater Use and Elevation CVP deliveries under Alternative 2 would be similar to those under the No Action Alternative. Consequently, groundwater use and elevation will be similar under Alternative 2 compared to the No Action Alternative.

Changes to Land Subsidence Under Alternative 2, based on CVP deliveries, groundwater levels and elevations would be similar to the No Action Alternative. Consequently, land subsidence under Alternative 2 will be similar to the No Action Alternative.

Changes to Groundwater Quality Under Alternative 2, based on CVP deliveries, groundwater levels and elevations would be similar to the No Action Alternative. Consequently, groundwater quality under Alternative 2 will be similar to the No Action Alternative.

Delta

Changes to Groundwater Use and Elevation CVP deliveries under Alternative 2 would be similar to those under the No Action Alternative. Consequently, groundwater use and elevation will be similar under Alternative 2 compared to the No Action Alternative.

Changes to Land Subsidence Under Alternative 2, based on CVP deliveries, groundwater levels and elevations would be similar to the No Action Alternative. Consequently, land subsidence under Alternative 2 will be similar to the No Action Alternative.

Changes to Groundwater Quality Under Alternative 2, based on CVP deliveries, groundwater levels and elevations would be similar to the No Action Alternative. Consequently, groundwater quality under Alternative 2 will be similar to the No Action Alternative.

San Francisco Bay Area

Changes to Groundwater Use and Elevation CVP deliveries under Alternative 2 would be similar to those under the No Action Alternative. Consequently, groundwater use and elevation will be similar under Alternative 2 compared to the No Action Alternative.

Changes to Land Subsidence Under Alternative 2, based on CVP deliveries, groundwater levels and elevations would be similar to the No Action Alternative. Consequently, land subsidence under Alternative 2 will be similar to the No Action Alternative.

Changes to Groundwater Quality Under Alternative 2, based on CVP deliveries, groundwater levels and elevations would be similar to the No Action Alternative. Consequently, groundwater quality under Alternative 2 will be similar to the No Action Alternative.

Summary of Impact Analysis

Table 6-1 presents the results of the environmental consequences analysis for implementing the action alternatives compared to the No Action Alternative.

Table 6-1. Comparison of Action Alternatives to No Action Alternative

Alternative	Potential Change	Consideration for Mitigation Measures
Alternative 1	Groundwater use and elevation, land subsidence, and groundwater quality would be similar to the No Action Alterative for all year types except critical years. In portions of the Sacramento and San Joaquin Valleys, reduced surface water deliveries could increase demands on groundwater and potentially-adversely impact groundwater use and elevation, subsidence and water quality.	Reductions in water deliveries may lead to increased groundwater pumping. The magnitude of increased groundwater pumping would be minor and no mitigation is identified.
Alternative 2	No effects on groundwater resources/groundwater quality. Groundwater use and elevation, land subsidence, and groundwater quality would be similar to the No Action Alterative for all year types.	None needed

Potential Mitigation Measures

Changes in CVP operations under action alternatives, as compared to the No Action Alternative, would not result in substantial changes in groundwater resources. Therefore, there would be no adverse impacts to groundwater resources, and no mitigation measures are required.

Cumulative Effects Analysis

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 groundwater resources and groundwater quality are summarized in Table 6-2. The methodology for this cumulative effects analysis is described in the Cumulative Effects Technical Appendix.

Table 6-2. Summary of Cumulative Effects on Groundwater Resources of Action Alternatives as Compared to the No Action Alternative

Scenarios	Cumulative Effects of Actions
No Action Alternative with Associated Cumulative Effects Actions in Year 2030	*Conditions and Actions included in Quantitative Analyses* *(Conditions and actions incorporated into No Action Alternative modeling)* Climate change and sea-level rise, development under general plans, FERC relicensing projects, and some future projects to improve water quality or habitat are anticipated to reduce the availability of CVP and SWP water supplies; and therefore, potentially increase groundwater use, reduce groundwater elevations, increase subsidence, and degrade groundwater quality. *Additional Identified Actions* *(Additional reasonably foreseeable projects or actions identified in Cumulative Effects Technical Appendix)* Additional reasonably foreseeable actions considered under this cumulative effects analysis are not anticipated to affect groundwater resources (use, elevation, quality) or subsidence.
Alternative 1 with Associated Cumulative Effects Actions in Year 2030	*Alternative 1 with Conditions and Actions included in Quantitative Analyses* Implementation of Alternative 1 may result in increased groundwater use, particularly in dry and critically dry years, as compared to the No Action Alternative, potentially resulting in cumulatively adverse impacts to groundwater use, groundwater elevations, groundwater quality, and subsidence. *Alternative 1 with Additional Identified Actions* The additional reasonably foreseeable actions are not anticipated to affect groundwater resources (use, elevation, quality) or subsidence.
Alternative 2 with Associated Cumulative Effects Actions in Year 2030	*Alternative 2 with Conditions and Actions included in Quantitative Analyses* Implementation of Alternative 2 would result in similar groundwater conditions (use, elevation, quality, subsidence) as compared to the No Action Alternative. *Alternative 2 with Additional Identified Actions* The additional reasonably foreseeable actions are not anticipated to affect groundwater resources (use, elevation, quality) or subsidence.

Key:
CVP = Central Valley Project
FERC = Federal Energy Regulatory Commission
SWP = State Water Project

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Chapter 7
Biological Resources – Fisheries

Introduction

This chapter describes fish and aquatic 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 these resources as a result of augmenting flows in the lower Klamath River in an effort to reduce the likelihood, and potentially reduce the severity, of any *Ichthyophthirius multifiliis* (Ich) epizootic event that could lead to an associated fish die-off in future years.

Regulatory Environment and Compliance Requirements

Federal or State regulations relevant to implementation of the alternatives evaluated in this EIS for fisheries resources include:

- **Endangered Species Act** – The Federal Endangered Species Act (ESA) applies to proposed Federal, State, and local projects that may result in the "take" of a fish or wildlife species that is Federally listed as threatened or endangered and to actions that are proposed to be authorized, funded, or undertaken by a Federal agency and that may jeopardize the continued existence of any Federally-listed fish, wildlife, or plant species or which may adversely modify or destroy designated critical habitat for such species.

- **Magnuson-Stevens Fishery Conservation and Management Act** – The Magnuson-Stevens Fishery Conservation and Management Act, as amended by the Sustainable Fisheries Act (Public Law 104-297), requires that all Federal agencies consult with National Marine Fisheries Service (NMFS) on activities or proposed activities authorized, funded, or undertaken by that agency that may adversely affect Essential Fish Habitat (EFH) for commercially managed marine and anadromous fish species.

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 fish and aquatic resources may occur in the Lower Klamath and Trinity River Region and in the Central Valley and Bay-Delta Region because of the changes in Trinity River Division (TRD) operations to provide increased flows in the lower Klamath River during the late-summer. The purpose of the flow augmentation is to protect the returning adult salmon population as they migrate and hold in the Klamath River below the Trinity River confluence.

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

Fish 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 augmenting flows in the lower Klamath River through operational changes of the TRD, as summarized in Table 7-1. Fish are evaluated both at the species level, and at the Evolutionarily Significant Unit (ESU) or distinct population segment (DPS), where relevant. An ESU is "a population (or group of populations) that (1) is substantially reproductively isolated from other conspecific population units, and (2) represents an important component in the evolutionary legacy of the species (Waples 1995). A DPS is a population (or group of populations) that is discrete from other populations of the species, and significant in relation to the entire species.

While many of the species identified in Table 7-1 also occur in tributaries to the major rivers, the focus of this EIS is on the lower Klamath River and the waterbodies influenced by operational changes of the Central Valley Project (CVP). TRD and CVP operations 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 Klamath River and the Sacramento-San Joaquin River and associated tributaries) that enter the Pacific Ocean and become available as a food supply for the whales.

The purpose of the proposed action is to reduce the likelihood, and potentially reduce the severity, of any Ich epizootic that could lead to an associated fish die-off in future years. Of the fish that did not survive in the 2002 die-off, 96 percent were fall-run Chinook Salmon, nearly 2 percent were steelhead, and 1 percent were Coho Salmon (DFG 2004). These species and other focal species are evaluated in this chapter. Focal species are fish listed as threatened or endangered, or at risk of being listed as endangered or threatened, and are legally protected, or are otherwise considered sensitive by the U.S. Fish and Wildlife Service (USFWS), 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.

Table 7-1. Focal Fish Species Evaluated by Region of Occurrence

Species or Population[a]	Federal Status	State Status[b]	Tribal, Commercial, or Recreational Importance	Occurrence within Area of Analysis
Lower Klamath and Trinity River Region				
Coho Salmon *Southern Oregon/Northern California Coast ESU*	Threatened	Threatened	Yes	Trinity River, Klamath River
Chinook Salmon *Southern Oregon/Northern California Coasts ESU*	None	None	Yes	Klamath River
Chinook Salmon *Upper Klamath-Trinity River ESU*	None	Species of Special Concern[c]	Yes	Trinity River, Klamath River
Steelhead (winter- and summer-run) *Klamath Mountains Province DPS*	None	Species of Special Concern[d]	Yes	Trinity River, Klamath River
Green Sturgeon *Southern DPS*	Threatened	Species of Special Concern	Yes	Lower Klamath River and Estuary
Green Sturgeon *Northern DPS*	None	Species of Special Concern	Yes	Trinity River, Klamath River
Eulachon *Southern DPS*	Threatened	None	Yes	Klamath River
Pacific Lamprey	None	Species of Special Concern	Yes	Trinity River, Klamath River
Black Bass (Largemouth, Smallmouth, Spotted)	None	None	Yes	Trinity Lake, Lewiston Reservoir
Central Valley and Bay-Delta Region				
Winter-run Chinook Salmon *Sacramento River ESU*	Endangered	Endangered	Yes	Sacramento River[e], Bay-Delta
Spring-run Chinook Salmon *Central Valley ESU*	Threatened	Threatened	Yes	Clear Creek, Sacramento River, Feather River, and Bay-Delta
Steelhead *Central Valley DPS*	Threatened	None	Yes	Clear Creek, Sacramento River; Feather River, American River, and Bay-Delta
Green Sturgeon *Southern DPS*	Threatened	Species of Special Concern	Yes	Sacramento River, Feather River, and Bay-Delta
Delta Smelt	Threatened	Endangered	No	Sacramento River and Bay-Delta

Table 7-1. Focal Fish Species Evaluated by Region of Occurrence (contd.)

Species or Population[a]	Federal Status	State Status[b]	Tribal, Commercial, or Recreational Importance	Occurrence within Area of Analysis
Central Valley and Bay-Delta Region (contd.)				
Longfin Smelt *Bay Delta DPS*	Candidate	Endangered	No	Bay-Delta
Fall-/Late Fall-run Chinook Salmon *Central Valley ESU*	None	Species of Special Concern	Yes	Clear Creek, Sacramento River, Feather River, American River, and Bay-Delta
Black Bass (Largemouth, Smallmouth, Spotted)	None	None	Yes	Whiskeytown Lake, Shasta Lake, Oroville Lake, Folsom Lake

Notes:
a. The term population refers to the listed 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 spring-run of the upper Klamath-Trinity River ESU Chinook Salmon population.
d. The California Species of Special Concern designation refers only to the summer-run of the Klamath Mountains Province DPS steelhead population.
Key:
DPS = Distinct Population Segment
ESU = Evolutionarily Significant Unit

The level of detail presented in the *Affected Environment* section is tailored to correspond with the level of resolution of the analysis, which relies on modeling tools that broadly characterize the changes in flows in the lower Klamath River and changes in CVP 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.

Critical Habitat and Primary Constituent Elements

Critical habitat are areas designated by USFWS or NMFS for the conservation of their jurisdictional species listed as threatened or endangered under the 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. The conservation value of listed species critical habitat is determined by the conservation value of the watersheds that make up the designated area. In turn, the conservation value of the elements that make up the habitat is the sum of the value of the primary constituent elements (PCE) within the area. PCEs are physical and biological features essential to the conservation of the species including space for individual and population growth and for normal behavior; food, water, air, light, minerals, or other nutritional or physiological requirements; cover or shelter; and sites for breeding, reproduction, and rearing of offspring. The conservation value of the PCEs is the sum of the quantity, quality, and availability of the essential features of that PCE. [1]

[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.”

Critical habitat and specific PCEs identified for salmonids, Green Sturgeon, Delta Smelt, and Eulachon are described below.

Southern Oregon/Northern California Coastal Coho Salmon ESU Critical Habitat The Southern Oregon/Northern California Coast Coho Salmon ESU consists of populations from Cape Blanco, Oregon, to Punta Gorda, California, including Coho Salmon inhabiting the Klamath and Trinity Rivers. In the Trinity River Region, all Trinity River reaches downstream from Lewiston Dam, the South Fork Trinity River, and the entire lower Klamath River are designated as critical habitat with the exception of tribal lands (64 Federal Register (FR) 24049).

Sacramento River Winter-run Chinook Salmon ESU Critical Habitat 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 Sacramento-SanJaoquin River Delta (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 (58 FR 33212).

Central Valley Spring-run Chinook Salmon ESU Critical Habitat 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; 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.

Central Valley Steelhead DPS Critical Habitat 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, 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.

Anadromous Salmonids PCE In designating critical habitat for anadromous salmonids (70 FR 52536), NMFS defined the PCEs essential to the conservation of the listed salmonids to include:

- Spawning sites with water quantity and quality conditions and substrate to support spawning, incubation, and larval development.
- Freshwater rearing sites with:
  - Water quantity and floodplain connectivity to form and maintain physical habitat conditions to support juvenile growth and mobility
  - Water quality and forage to support juvenile development
  - Natural cover (e.g., shade, submerged and overhanging large wood, aquatic vegetation, large rocks, and undercut banks)
- Freshwater migration corridors free of obstruction and excessive predation and having water quantity and quality conditions and natural cover to support juvenile and adult mobility and survival.
- Estuarine areas free of obstruction and excessive predation with:
  - Water quality, water quantity, and salinity conditions to support juvenile and adult physiological transitions between fresh water and salt water
  - Natural cover
  - Juvenile and adult forage, including aquatic invertebrates and fishes, to support growth and maturation

Southern DPS of the North American Green Sturgeon PCE and Critical Habitat

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

- Abundant prey items for larval, juvenile, subadult, and adult life stages
- Substrates suitable for egg deposition and development, larval development, and subadults and adults
- 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, including temperature, salinity, oxygen content, and other chemical characteristics, necessary for normal behavior, growth, and viability of all life stages

- A migratory pathway suitable for safe and timely passage in riverine habitats and between riverine and estuarine habitats (e.g., an unobstructed river or dammed river that still allows for safe and timely passage)

- Deep (greater than 5 meters) 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 (i.e., chemical characteristics) necessary for normal behavior, growth, and viability of all life stages

Within the study area, critical habitat for the southern DPS Green Sturgeon encompasses 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 its confluence with the Sacramento River upstream to the State Route 160 bridge over the American River; the lower Feather River from its confluence with the Sacramento River upstream to the Fish Barrier Dam; and the lower Yuba River from its 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 (74 FR 52300).

Delta Smelt PCE and Critical Habitat

In designating critical habitat for Delta Smelt (59 FR 65256), USFWS identified the following PCEs essential to their conservation:

- Suitable substrate for spawning

- Water of suitable quality and depth to support survival and reproduction (e.g., temperature, turbidity, lack of contaminants)

- Sufficient Delta flow to facilitate spawning migrations and transport of larval Delta Smelt to appropriate rearing habitats

- 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) (59 FR 65256).

Eulachon Southern DPS Critical Habitat

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 reflecting key life history phases of Eulachon:

- Freshwater spawning and incubation sites with water flow, quality and temperature conditions and substrate to support spawning and incubation, and with migratory access for adults and juveniles

- 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

- Nearshore and offshore marine foraging habitat with water quality and available prey, supporting juvenile and adult survival

Within the study area, critical habitat for Eulachon includes the Klamath River from its mouth upstream to the confluence with Omogar Creek. The critical habitat designation specifically excludes all lands of the Yurok Tribe and Resighini Rancheria, based upon a determination that the benefits of exclusion outweigh the benefits of designation (NMFS 2011). 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 percentile of the total annual production for the DPS (NMFS 2011).

Essential Fish Habitat

In response to growing concern about the status of United States fisheries, Congress passed the Sustainable Fisheries Act of 1996 (Public Law 104-297) to amend the Magnuson-Stevens Fishery Conservation and Management Act (Public Law 94-265), the primary law governing marine fisheries management in the Federal waters of the United States. Under the Sustainable Fisheries Act, consultation is required by NMFS on any activity that might adversely affect essential fish habitat (EFH). EFH includes those habitats on which fish rely throughout their life cycles, including waters and substrate necessary for spawning, feeding, and growth to maturity. It encompasses habitats necessary to allow sufficient production of commercially valuable aquatic species to support a long-term sustainable fishery and contribute to a healthy ecosystem. EFH for Pacific salmon includes fresh water systems currently or historically accessible to salmon, and nearshore and marine environments up to 200 miles offshore.

Klamath and Trinity River Region

For this EIS, the Klamath and 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 from its confluence with the Trinity River to the Pacific Ocean. The Trinity River flows approximately 112 miles from Lewiston Reservoir to its confluence with the Klamath River, traversing through the Hoopa Valley Indian Reservation. The Trinity River is the largest tributary of the Klamath River (DOI and DFG 2012).

The lower Klamath River flows 43.5 miles from its confluence with the Trinity River to the Pacific Ocean (USFWS and Hoopa Valley Tribe 1999). Downstream from the Trinity River confluence, the Klamath River flows through the Yurok Indian Reservation and Resighini Rancheria (DOI and DFG 2012). There are no dams located in the Klamath River watershed downstream of its confluence with the Trinity River. The Klamath River estuary extends

approximately 5 miles upstream of the Pacific Ocean. This area is generally under tidal effects, and salt water can occur up to 4 miles upriver from the coastline during high tides in summer and fall when Klamath River flows are low.

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, Yellow Perch, 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, Coastrange Sculpin, and Smallmouth Bass (USFWS et al. 2004).

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 and Pacific Lamprey.

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 encroached 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 and Hoopa Valley Tribe 1999).

The ongoing Trinity River Restoration Program includes specific dedicated instream water volumes that vary by water year type (as described in Chapter 4, “Surface Water Supply and Management”); mechanical channel rehabilitation; fine and coarse sediment management; watershed restoration; infrastructure improvement; and adaptive management components (NCRWQCB et al. 2009, USFWS and Hoopa Valley Tribe 1999). The mechanical channel rehabilitation includes construction of bar surfaces, floodplain lowering and reconnection, side channel construction, and removal of fossilized riparian berms that had been anchored by extensive woody-vegetation root systems that confined the river. Following mechanical rehabilitation, the altered areas have been re-vegetated to support native vegetation. Sediment management activities include introduction of coarse sediment at locations to support spawning and other aquatic life stages. 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 is planted on restored floodplains and flows are managed to encourage natural riparian growth on the floodplain and limit encroachment on the newly formed gravel bars. Some improvement projects have been completed and others are under construction

or in the planning phase. These restoration actions are occurring in the 40-mile restoration reach between Lewiston Dam and the confluence with the North Fork Trinity River (TRRP 2014).

Lower Klamath River from Trinity River to Pacific Ocean

The lower Klamath River begins where the Trinity River flows into it near Weitchpec, 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 its confluence with the Trinity River or in the larger tributaries (e.g., Blue Creek) to the mainstem Klamath River.

Fish Species in the Klamath and Trinity River Region The focal fish species that occur in the Klamath and Trinity River Region are identified in Table 7-1, and detail of their life histories are provided below.

Southern Oregon/Northern California Coast Coho Salmon Coho Salmon (*Oncorhynchus kisutch*) in the Trinity River are in the Southern Oregon/Northern California Coast (SONCC) Coho Salmon ESU, and were listed as threatened under the ESA in 1997 (62 FR 24588, May 6, 1997) and threatened under the California Endangered Species Act in 2002. This ESU includes naturally-spawning populations between Punta Gorda, California, and Cape Blanco, Oregon, which encompasses the Klamath River Basin (which includes the Trinity River) (62 FR 24588, May 6, 1997). This ESU includes three artificially-propagated stocks. Additionally, Coho Salmon in the Klamath Basin have been listed by the California Fish and Game Commission as threatened under the California Endangered Species Act.

Coho Salmon in the Trinity River are thought to be primarily 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 River confluence (NMFS 2014a). After emergence, fry move into areas out of the main current, and as they grow, they spread out from the areas where they were spawned. During summer, juveniles prefer pools and riffles with adequate cover such as large woody debris with smaller branches, undercut banks, and overhanging vegetation and roots.

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. The smolts[2] typically migrate to the ocean between March and June, with most leaving in April and May.

Passage for Coho Salmon and other anadromous salmonids is now blocked by Lewiston Dam, preventing access to roughly 109 miles of upstream historical habitat for Coho Salmon (DOI and Hoopa Valley Tribe 2000). The Trinity River Hatchery produces Coho Salmon with an annual production goal of 300,000 yearlings to mitigate the upstream habitat loss (CHSRG 2012, USDC 2014).

[2] The term *smolt* refers to young salmon prior to entering the ocean that have undergone the physiological changes necessary for life in salt water

The run-size estimates have ranged from 852 fish in 1994 to 59,079 fish in 1987. 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).

Upper Klamath and Trinity Rivers Spring-Run Chinook Salmon The Upper Klamath and Trinity Rivers ESU includes fall- and spring-runs of Chinook Salmon (*O. tshawytscha*) that spawn in the Klamath and Trinity Rivers upstream of the Trinity River's confluence with the Klamath. Although wild spring-run Chinook Salmon in the Klamath River system differ to a degree from fall-run Chinook Salmon genetically, and in life history and habitat requirements (NRC 2004), both are included within this ESU (Myers et al. 1998). A petition to list the Upper Klamath and Trinity Rivers ESU was submitted to NMFS in January 2011 (CBD et al. 2011); in April 2011, NMFS announced that listing was not warranted. Of primary importance in their decision was their conclusion that the spring-run and fall-run Chinook Salmon in the basin constitute a single ESU (77 FR 19597). Three hatchery stocks from the Iron Gate (fallrun) and Trinity River (spring and fall runs) Hatcheries are considered part of the ESU because they were founded using native, local stock in the watershed where fish are released (77 FR 19597).

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 in early 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.

Emergence of spring-run Chinook Salmon fry in the Trinity River begins in December and continues into mid-April. Juvenile spring-run Chinook Salmon exhibit both ocean-type and stream-type rearing. That is, they may rear for a short period in the Trinity River and outmigrate to sea in the spring or fall after hatching (ocean-type), or rear in the Trinity River for a year and outmigrate to sea 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.

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. 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).

Upper Klamath and Trinity Rivers 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 early October. Spawning activity peaks in late October, and continues through December. Fall-run Chinook Salmon spawning occurs throughout the mainstem Trinity River from Lewiston Dam to the Hoopa Valley (Myers et al. 1998).

Trinity River fall-run Chinook Salmon fry begin emerging from the spawning beds in January and continue 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.

Southern Oregon/Northern California Coast Chinook Salmon The SONCC Chinook Salmon ESU includes all naturally-spawned Chinook salmon in the lower Klamath River downstream from its confluence with the Trinity River. In 1999, NMFS determined that this ESU did not warrant listing, nor did they identify the SONCC Chinook Salmon as a species of concern. Their life history traits are similar to the Upper Klamath and Trinity River Chinook Salmon. They are principally a late fall-run Chinook Salmon, entering the rivers to spawn between September and December. Spawning takes place between October and February. These ocean-type fish remain in fresh water for four to six months before migrating back out to sea.

Klamath Mountains Province Steelhead Steelhead (*O. mykiss*) 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 occur in the north and south forks of the Trinity River and in the New River and Canyon Creek tributaries (BLM 1995).

Adult summer-run steelhead enter the Trinity River from April through September and over-summer in deep pools in the mainstem and large tributaries. 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. Comprehensive synoptic, post-dam surveys of Trinty basin-wide summer steelhead populations have not been regularly compiled; however, numbers of over-summering adult steelhead in the North Fork Trinity River from 1990-97 ranged from 20 to 1,037 (Everest 1997). Additionally, redd surveys (during and after spawning by both summer and fall runs) in a number of other tributaries of the Trinity River, including the South Fork Trinity River, suggests populations within the same range for populations in other tributaries (Hill 2008, 2010).

Juvenile summer-run steelhead may rear in fresh water for up to three years before outmigrating, and freshwater rearing histories of Trinity River steelhead are highly variable (Scheiff et al. 2001, Pinnix and Quinn 2009, Pinnix et al. 2013, Hodge et al. 2016). 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). 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 (*Acipenser medirostris*) 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).

The northern DPS of 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 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). Juveniles 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), usually during summer and fall (Emmett et al. 1991, Hardy and Addley 2001).

In the Trinity River Basin, the northern DPS of Green Sturgeon are known to spawn in the mainstem from the confluence with the Klamath River 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). The southern DPS of Green Sturgeon may use the lower Klamath River and estuary periodically for juvenile and adult rearing.

Pacific Lamprey Pacific Lamprey (*Entosphenus tridentatus*) are the only anadromous lamprey species in the Trinity River Basin. This species is important to local tribes and supports subsistence fisheries on the Klamath River and 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 what has been 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).

Eulachon Eulachon (*Thaleichthys pacificus*) 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. Most Eulachon are sexually mature at 3 years though some spawn at ages 4 or 5. A few fish may spawn again the following year, but most die after their first spawn (Moyle 2002). 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 far upstream as Brooks Riffle, about 24 miles upstream of the mouth, but they have been observed as high as Pecwan Creek and even Weitchpec during exceptional years (YTFP 1998); yet 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 stay near the bottom and are then washed out to the ocean (Moyle 2002).

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 large 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, Yurok Tribal Fisheries Program (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).

Current Understanding of Fish Disease Processes in the Lower Klamath River

A number of important fish pathogens, which can cause disease, occur in the Klamath River basin, including Ich, the protozoan causative agent of white spot disease; *Ceratonova shasta* and *Parvicapsula minibicornis*, both myxosporean parasites of salmon that have a polychaete worm (*Manayunkia speciosa*) intermediate host prior to infecting juvenile salmonids; and *Flavobacterium columnare*, bacterial causative agent of columnaris disease (Foott 2003, Guillen 2003, DFG 2004, NRC 2004, Nichols et al. 2003 and 2008, Bartholomew and Foott 2010, True and Foott 2012, Foott et al. 2016).

Ceratomyxosis, caused by *C. shasta* infections, has been the most significant disease for juvenile salmon in the Klamath River Basin (Bartholomew and Foott 2010). This pathogen is particularly abundant in the Klamath River from Iron Gate Dam to Seiad Creek (river mile [RM] 190 – 141). Favorable conditions for its intermediate host polychaete worm occur in this reach of the Klamath River, including relatively low-velocity habitats with a silty, detrital river bottom and abundant filamentous green algae that supports dense and persistent populations of *M. speciosa* (Bartholomew and Foott 2010). Additionally, relatively high densities of returning adult salmon in this reach and high abundance of juveniles released from Iron Gate Hatchery are thought to facilitate the parasite’s life cycle and contribute to particularly high concentrations of infective

stages of both *C. shasta* and *P. minibicornus* (True et al. 2012). Despite the resistance to *C. shasta* exhibited by native sympatric salmonid populations, juvenile salmon exposed to high levels of the parasite, particularly at high temperatures, appear to be more susceptible to the disease (Bartholomew and Foott 2010). Many juvenile salmonids originating in upstream reaches of the Klamath River pass through the reach favoring the *C. shasta* life cycle during their spring outmigration at a time when *C. shasta* infectivity appears to be high and are reported to have a high incidence of infection by *C. shasta* and *P. minibicornis* (10 to 70 percent), with disease-related mortality rates as high as 35 to 70 percent (Nichols and Foott 2005, Beeman et al. 2008).

The nature and agents of disease in adult salmon returning to the Klamath River Basin are different than that described for juvenile salmon, and disease outbreaks and mortality have generally been less frequent in adult salmon (DFG 2004). Ich and columnaris disease are commonly reported diseases in adult salmon returning to the Klamath River and other rivers along the Pacific Coast and are often associated with pre-spawning mortality of salmon (Fagerlund et al. 1995, DFG 2004). The two pathogens that cause these diseases are widespread, regularly occur on healthy fish (though not at levels causing disease), and typically become lethal only when fish experience high degrees of stress[3] (Fagerlund et al. 1995, Winton 2001, DFG 2004). Crowding may be considered one factor that elicits a stress response in fish and contributes to efficient transmission of pathogens from one fish to another (Guillen 2003, DFG 2004).

As described and reviewed by DFG (2004) and Strange (2010a, 2015), the life cycle of the Ich pathogen, *I. multifilii*s, is direct (with no intermediate host). The parasitic stage of Ich is called the trophont and resides on the fish. After feeding, the parasite drops off the fish as a tomont, attaches to substrate where it encysts, and replicates many tomites. The cyst bursts and releases many short lived theronts which must successfully invade and attach to fish host tissue to continue the life cycle. The rate of infection is temperature dependent and increases at temperatures from 55 degrees Fahrenheit (°F) and warmer (Traxler et al. 1998, Winton 2001, DFG 2004). At optimal temperatures of 68 to 73.4°F, which are common in the lower Klamath River during the late summer, the entire Ich life cycle may take from four to seven days, with the trophonts residing on fish for three to five days, tomonts drop off and divide into many tomites in less than one to two days, and the released free-swimming, infectious theronts must find a fish host within about 24 hours. The cycle can be completed more quickly at warmer temperatures, but requires two weeks at 59°F, more than five weeks at 50°F, and months at lower temperatures (Post 1987, Winton 2001).

The pathogenicity of Ich disease is related to the fish immune response primarily at infection sites on gill and skin tissues (Post 1987, Fagerlund et al. 1995). The very thin walled epithelial cells of the gills facilitate oxygen and carbon dioxide gas exchange between the blood and oxygen-supplying water. When the Ich parasite infects this tissue—a preferred site because of the blood rich nutrient supply accessible to the parasite—an inflammatory immune response of the fish can result in fluid edema and hyperplasia (a thickening and proliferation of cells) of the gill tissue (Post 1987). This reduces the efficiency of gas exchange across the gills, reducing the ability of fish to obtain necessary oxygen and disrupting blood pH regulation. Infections of the

[3] Stress as used here refers to a state produced by any environmental factor that alters the normal behavioral and physiological adaptive responses of an animal to such an extent that the chances of survival are significantly reduced.

skin integument can lead to leaky cells and disruption of osmoregulatory function (Post 1987, Winton 2001, DFG 2004). Columnaris infections are usually secondary to Ich infections and other injuries that expose tissues vulnerable to bacterial infection (Post 1987, Fagerlund et al. 1995, Winton 2001, Foott 2003).

The primary factors currently thought to contribute to infection dynamics and outbreaks of Ich disease in adult salmon returning to the Klamath River are:

- A background presence and reservoir of Ich parasites carried by the resident freshwater fishes of the lower Klamath River, primarily Speckled Dace (*Rhinichthys osculus*) and, perhaps other fish species including Klamath Smallscale Sucker (*Catostomous rimiculus*), with background levels varying from year-to-year but may be higher in years following large-scale outbreaks of Ich, even when disease or pre-spawning mortality of salmon does not result (Belchik 2015, Strange 2015, Foott et al. 2016).

- High water temperatures in the lower Klamath River, ≥73.4°F, during late summer into early fall that can result in thermal barriers that slow or delay migration of adult salmon. Salmon that arrive from the ocean and encounter these elevated temperatures can congregate in limited thermal refuge habitats, slowing migration through the lower Klamath River as they experience elevated physiological stress, contributing to high replication rates of the Ich parasites (Guillen 2003, DFG 2004, Strange 2010a, 2010b and 2012, USFWS and NMFS 2013, Belchik 2015).

- Low-flow conditions, which are often associated with high water temperatures, can result in limited areas of holding habitat and slowed migration for adult salmon in the lower Klamath River, where they stage until conditions for continuing migration improve, leading to abundant congregations of fish in these limited staging areas, especially near cooler temperature refuges at the mouths of tributaries (DFG 2004, Strange 2012, Belchik 2015).

- Presence of adult salmon in the lower Klamath River. In particular, large run size and high abundance of fall-run Chinook Salmon in the lower Klamath River generally increases the density of holding fish in the lower river that, in turn, can favor transmission and infectivity of the Ich parasite due to the close proximity of fish in limited holding habitats, leading to outbreaks of infection. However, adult salmon tend to congregate in close proximity to each other (schooling behavior) even with smaller runs or low fish abundance, and outbreaks can still occur during smaller run sizes if other variables are favorable to Ich transmission (Foott 2003, DFG 2004, Belchik 2015, Strange 2015).

The combination and convergence of these factors contribute to prime conditions for infections and transmission of the Ich parasite between fish. When densities of the host fish are high, the likelihood of the infectious tomite stage finding a host is high. When the temperature is high, parasite reproduction rate is increased and heavy parasite loads and burdens in fish can result. This may or may not result in fish mortality; for example, in 2014, infection rates were reported to be relatively high, without significant adult moratlity (Belchik 2015). Gill epithelia damaged by heavy parasite loads exacerbates the fishes' ability to obtain oxygen from water that may

already be depressed in oxygen by warm water temperature and crowded holding pools where dissolved oxygen levels can be reduced due to respiration by the mass of fish inhabiting the pools (CDFW 2004). Accordingly, management measures that have been applied since the 2002 fish die-off in the lower Klamath River, as described in Chapter 1 "Introduction" and that are further considered and evaluated in this Draft EIS, focus on alleviating one or more of the contributing factors and disrupting the life cycle of the Ich parasite that may cause disease and potentially lead to pre-spawning mortality of adult salmon (USFWS and NMFS 2013, Reclamation 2016).

Central Valley and Bay-Delta Region

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

- Shasta Lake
- Whiskeytown Lake
- Clear Creek
- Sacramento River, from Keswick Reservoir to the Delta
- Feather River
- American River
- Bay-Delta

Shasta Lake

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. Keswick Dam reregulates releases from Shasta Dam to the Sacramento River and has no fish passage facilities; however, Keswick Dam has a fish trapping facility that operates in conjunction with Livingston Stone National Fish Hatchery, which is located below Shasta Dam.

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 2014). 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°F (Reclamation 2014). 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 2014). 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 2014).

Warm-water fish habitat in Shasta Lake is influenced primarily by fluctuations in the lake level and the availability of shoreline cover (Reclamation 2014). Water surface elevations in Shasta

Lake can fluctuate approximately 55 feet annually as a result of operation of Shasta and Sacramento River diversions (Reclamation 2014). 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 2014).

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 was replaced in 2016 and 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 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, Brook Trout, Brown Trout, Kokanee Salmon, Largemouth Bass, crappie, sunfish, catfish, and bullhead (USFWS et al. 2004).

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 (NMFS 2009). 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.

Extent and Status of Aquatic Habitat Whiskeytown Dam limits the contribution of coarse sediment for transport downstream in Clear Creek, which NMFS (2009) 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 temperature conditions on Clear Creek are presented in Chapters 4 and 5, “Surface Water Supply and Management,” and “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.

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 2007a). 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. 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 estimate the availability of fish habitat, expressed as Weighted Usable Area (WUA), have been conducted by USFWS for Clear Creek (USFWS 2007b). Over the range of flow evaluated, from 50 to 900 cubic feet per second (cfs), WUA for spring-run Chinook Salmon spawning was highest at 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), estimated spawning habitat WUA peaked at 650 cfs. The WUA estimates for steelhead/Rainbow Trout spawning habitat peaked at 350 cfs and 600 cfs in these segments, respectively (USFWS 2007b). In the lower reach downstream of the Clear Creek Road Bridge, estimated WUA for both fall-run Chinook Salmon and steelhead/Rainbow Trout spawning habitat peaked at 300 cfs (USFWS 2011a).

USFWS (2007) concluded that at all flows evaluated, the estimated amount of spawning habitat present in Clear Creek was less than that needed to accomodate an an average escapement of 833 spring-run Chinook Salmon, an escapement that meets “low risk of extinction criteria” (NMFS 2014b). 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 was greater than the amount of spawning habitat needed to accomodate 833 spawning adults for steelhead. The amount of spawning habitat present in Clear Creek was less than the amount of spawning habitat needed to support the 2005 to 2013 avererage escapement of 7,920 adult fall-run Chinook Salmon in Clear Creek (USFWS 2015a).

Rearing Habitat The WUA estimate 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), estimated fry rearing habitat WUA peaked at the highest modeled flow of 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 2013).

USFWS (2015) compared the total amount of 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 was 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 was less than the amount needed to support the the 2005 to 2013 average annual excapement of 7,920 adult fall-run Chinook Salmon in Clear Creek.

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 an almost complete barrier to upstream migration for anadromous salmonids. After its removal, anadromous salmonids recolonized an additional 12 miles of habitat upstream to Whiskeytown Dam. 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 by operating a segregation weir from late August to November 1. After November 1, fall-run Chinook Salmon have access to the entire river for spawning.

Sacramento River from Keswick Dam 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 ones that provide more natural types of habitat. The flow regime in the Sacramento River is managed for water supply, flood risk reduction, and fish and wildlife resources as described in Chapter 4, “Surface Water Supply and Management.” The following discussion focuses on the fish in the Sacramento River and aquatic habitat conditions.

Aquatic Habitat The mainstem Sacramento River provides habitat for native and introduced 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.

A few miles downstream of Keswick Dam, near Redding, the valley and 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

Sacramento River between Red Bluff and Chico Landing, the mainstem channel is flanked by broad floodplains. 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 2009). 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 by flow patterns that are dominated 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. 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 2014). To address the issue of spawning gravel loss downstream of Keswick Dam, the U.S. Department of the Interior, Bureau of Reclamation (Reclamation) has placed an average of approximately 5,000 tons of washed spawning gravel into the Sacramento River downstream of Keswick about every other year since 1997 (Reclamation 2010). Gravel placements of higher quantities sometimes occur after years when high flows have evacuated gravel from the injection sites. Flows as high as 20,000 cfs were released from Keswick Dam in March 2016, and created room to inject 20,000 tons of gravel that were placed just downstream of Keswick Dam in September 2016.

Spawning Habitat Availability Winter-run Chinook Salmon spawning in the upper reaches of the Sacramento River is affected by the operations of the seasonal Anderson-Cottonwood Irrigation District (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.

The WUA for winter-run Chinook Salmon spawning peaked at around 10,000 cfs in the reach upstream of the ACID intake when the dam flashboards were in place. With the boards out, the peak was around 5,500 cfs. Between ACID intake and Cow Creek, spawning WUA also peaked at around 10,000 cfs. Between Cow Creek to Battle Creek, WUA spawning habitat peaked at around 5,250 cfs, but there was low variability in spawning WUA from 3,250 to 8,000 cfs (USFWS 2005a).

Overall, spawning habitat WUA values differed for fall-run and late fall-run Chinook Salmon, but the shapes of their flow versus habitat relationships were about the same for the two runs. Upstream of the ACID intake, estimated spawning habitat WUA for fall- and late fall-run

Chinook Salmon was highest 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 peaked at around 5,000 cfs for both runs. Between Cow Creek and Battle Creek, spawning habitat WUA for both runs peaked at about 3,500 cfs. The highest density of redds for fall- and late fall-run Chinook Salmon occur in the ACID intake to Cow Creek reach.

The estimated spawning habitat WUA value for steelhead were highest 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 peaked at river flows around 6,000 cfs. In the lower reach, from Cow Creek to Battle Creek, spawning habitat WUA also peaked at river flows of about 6,500 cfs, but did not vary substantially over the flow range from about 4,000 to 8,000 cfs.

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

USFWS (2005b) 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 the Red Bluff Pumping Plant (RBPP), 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, then 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 2005b).

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 floodplain processes can be significant within the river corridor (TNC 2007).

Fry rearing habitat WUA for winter-run Chinook Salmon fry rearing habitat peaked at around 5,500 cfs in the reach upstream of the ACID intake when the dam flashboards were in. With the boards out, the peak was around 6,500 cfs. Between ACID intake and Cow Creek, fry rearing habitat WUA for winter-run Chinook Salmon was highest at around 31,000 cfs (the highest flow evaluated). From 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 relationship between WUA and flows.

The fry rearing habitat WUA values differed for fall-run and late fall-run Chinook Salmon, but the shapes of the flow versus habitat relationships were similar for the two runs. Upstream of the ACID intake, fry rearing habitat WUA for fall- and late fall-run Chinook Salmon was highest at the lowest flow analyzed (3,250 cfs) with the dam flashboards in. With the flashboards out, fry

rearing habitat WUA peaked 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 was highest at 3,250 cfs (the lowest flow evaluated) and declined as flows increased.

Juvenile rearing habitat WUA for winter-run Chinook Salmon peaked at around 8,000 cfs in the upstream reach above the ACID intake when the dam flashboards were in. With the boards out, the peak was around 9,000 cfs. However, there was 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 was highest at around 31,000 cfs (the highest flow evaluated). From Cow Creek to Battle Creek, juvenile rearing habitat WUA for winter-run Chinook Salmon peaked at around 3,500 cfs but showed only moderate (less than 50 percent) reductions in WUA over the entire range of flows evaluated.

The juvenile rearing habitat WUA values differed for fall-run and late fall-run Chinook Salmon, but the shapes of their flow versus habitat relationships were similar. 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 (less than 50 percent) reductions in juvenile rearing WUA over the entire range of flows evaluated. Between the ACID intake and Cow Creek, fry rearing WUA was highest at 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 was highest at 3,250 cfs (the lowest flow evaluated) and declined 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 (2005a) conducted limiting life-stage analyses for winter-, fall-, and latefall-run Chinook Salmon in the Sacramento River above Battle Creek and found that in most cases, juvenile habitat was limiting. An important limitation of this analysis was 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 from Keswick Dam is 3,250 cfs from September through February in all but critical water years in accordance with State Water Resources Control Board water rights order 90-05. Flows during summer generally exceed 3,250 cfs. 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.

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). Access to approximately 207 miles was blocked with completion of Shasta Dam in 1945. 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 Glen-Colusa Irrigation District (GCID) intakes and the Red Bluff Diversion Dam (RBDD), were of particular concern as potential passage or entrainment problems for Chinook Salmon, steelhead, and other migratory fish species (NRC 2012, NMFS 2009). Recently, the RBDD was replaced by the more passage-friendly RBPP, 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 2009), rendering approximately 3 miles of spawning habitat upstream of the diversion dam inaccessible. 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. Vogel (2014) found that juvenile salmon were entrained in a much lower proportion than the proportion of flow diverted, 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.

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 2009). 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).

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 its 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).

Most Chinook Salmon and steelhead spawning is concentrated in the uppermost three 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 Salmon 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 2004).

Lower American River Between Lake Natoma and the Sacramento River

The lower American River extends approximately 23 miles from the Nimbus Dam downstream to its confluence with the Sacramento River. Access to the upper reaches of the river by anadromous fish is blocked at Nimbus Dam. 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 2009). In 2008, Reclamation began implementing floodplain and spawning habitat restoration projects in the American River, and has continued to do so nearly every year since from Nimbus Dam down to River Bend Park.

Bay-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 River, San Joaquin River, and east side tributary flows converge and tidal influences from San Francisco Bay are greater.

Aquatic Habitat Flow management in the Delta has created stress on aquatic resources by (1) changing aspects of the historical flow regime (i.e., timing, magnitude, duration) that supported life history traits of native species; (2) limiting access to habitat or degrading habitat quality; (3) contributing to conditions better suited to invasive, nonnative species (through 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 upon 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.

Water temperatures in the Delta follow a seasonal pattern of winter cold-water conditions and summer warm-water conditions 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 (Mount et al. 2012, NRC 2012, Wagner et al. 2011). Water temperatures in summer now approach or exceed the upper thermal tolerances for cold-water fish species such as salmonids and Delta-dependent species such as Delta Smelt (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).

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, the tolerance 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 freshwater 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). It also helps define the extent of habitat available for oligohaline pelagic organisms and their prey. 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 (Feyrer et al. 2007). CVP and State Water Project (SWP) operations and other potential factors (e.g., lower outflows) have shifted 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 (Kimmerer et al. 2009, Baxter et al. 2010).

Nutrients and Food Web Support Nutrients 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.

Estuaries are commonly characterized as highly productive nursery areas for numerous aquatic organisms. 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). There has been a significant long-term decline in phytoplankton biomass (chlorophyll a) and primary productivity at low levels in the Suisun Bay region and the Delta (Jassby et al. 2002). Shifts in nutrient concentrations such as a high level 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, 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. 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). Additionally, the introduced clams

caused the decline of higher-food-quality native copepods and the establishment of poorer quality nonnative copepods. Reductions in food availability and food quality have led to lower fish foraging efficiency and reduced growth rates (Moyle 2002).

Turbidity Turbidity is important in the Delta because it 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 impacts 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 2008).

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 Delta 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, 2008, 2010).

Baxter et al. (2008) prepared a 2007 synthesis of results as part of a Pelagic Organism Decline 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 study of sediment toxicity recommended additional study of the effects of the pyrethroid insecticides on benthic organisms (Weston et al. 2004). 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).

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 Bay-Delta. 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.

Juvenile fish moving down the mainstem Sacramento River can enter the DCC when the gates are open and travel through the Delta via the Mokelumne and San Joaquin Rivers' channels. In the case of juvenile salmonids, this shifted route from the north Delta to the central Delta increases their mortality rate (Brandes and McLain 2001, Newman and Brandes 2010, Perry et al. 2010, 2012). Closing the DCC gates redirects the migratory path of outmigrating fish into Sutter and Steamboat Sloughs and away from Georgiana Slough, resulting in higher survival rates (NMFS 2009).

The south Delta intake facilities include the CVP and SWP export facilities; local agency intakes, and agricultural intakes. 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. Delta diversions can create reverse flows, drawing fish toward project facilities (Arthur et al. 1996, Kimmerer 2008, Grimaldo et al. 2009).

A portion of fish that enter the CVP C.W. 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, 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).

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, 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.

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 Biological Opinion 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 (USFWS 2008).

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).

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.[4] 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).

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. 2007, 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).

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 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

[4] 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."

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.

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 for 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.

Fish Species in the Central Valley and Bay-Delta Region

The focal fish species that occur in the Central Valley and Bay-Delta Region are identified in Table 7-1, and detail of their life histories are provided below.

Fish in the CVP and SWP Reservoirs Fish in the CVP and SWP reservoirs consist of two basic types – warm-water and cold-water species. Warm-water fishes include the black bass,

consisting of Largemouth Bass, Smallmouth Bass and Spotted Bass. Cold-water fishes include salmonid species, including Rainbow Trout and in some cases, landlocked Chinook Salmon.

Largemouth Bass Largemouth Bass (*Micropterus salmoides*), native to the Mississippi River drainage and the southeastern United States, were first introduced into California in 1891 and have since spread to most suitable habitats in the State (Moyle 2002).

Largemouth Bass begin spawning in March or April and may spawn through June (Mitchell 1982, Moyle 2002). They typically build their nests on sand, gravel, or debris-littered substrates, often selecting sites next to logs or boulders that provide cover (Moyle 2002). Largemouth Bass generally spawn at depths between about 3 and 6 feet. The larvae rise from the nest and begin exogenous feeding about 5 to 8 days after hatching (Emig 1966). The males guard the nests and newly hatched larvae from predators, including Bluegill and Threadfin Shad (Mitchell 1982). Their optimal water temperatures for growth range from 77°F to 86°F (Moyle 2002). Juveniles prefer somewhat higher water temperatures than adults.

Smallmouth Bass Smallmouth Bass (*M. dolomieui*) are native to the upper and middle Mississippi River drainage. They were first introduced into California in 1874 and have since been widely distributed throughout the State (Moyle 2002). They have become established in many reservoirs and are normally found in cool waters, often near the upstream end of the impoundments. They also concentrate in narrow bays or areas along shores where rocky shelves project under water (Moyle 2002).

Spawning activity usually begins in spring when water temperatures reach 59°F to 61°F and ceases when temperatures reach about 78°F (Wang 1986, Cooke et al. 2003). The male guards the nest until the eggs hatch, which occurs between 3 and 10 days, depending on water temperature. The male herds and guards the fry for an additional 1 to 3 weeks until the fry disperse into shallower water. Fluctuations in reservoir water levels often interfere with success of Smallmouth Bass nests. Although Smallmouth Bass are typically found in cooler water than Largemouth and Spotted Bass, optimum temperatures for growth and survival are similar, approximately 77°F to 81°F (Moyle 2002).

Spotted Bass Alabama Spotted Bass (*M. punctulatus*) are native to the southeastern United States, but have been widely introduced into reservoirs because of their ability to spawn successfully in highly fluctuating water levels.

Spotted Bass begin spawning as early as late March, when the water temperature rises to 59°F to 65°F, and continues until temperatures reach 71°F to 73°F (Moyle 2002), with peak spawning occuring in late May and early June (Wang 1986). Males construct nests in colonies at depths of 3 to 20 feet (Wang 1986). The males guard the nests and newly-hatched larvae from predators such as bluegills (Aasen and Henry 1980). The larvae typically disperse from the nest 8 days after hatching (Vogele 1975). Growth is maximized at about 75°F (McMahon et al. 1984).

Fish in the Rivers Downstream from the CVP and SWP Reservoirs This section includes descriptions of the riverine fishes that occur downstream from the CVP and SWP reservoirs.

Sacramento River Winter-Run Chinook Salmon In 1989, Sacramento River winter-run Chinook Salmon escapement was estimated at 695 adults. Escapement continued to decline, ranging

between 185 and 1,240 fish between 1989 and 1994, with an average of 525 adults. The decline in escapement during the late 1980s and early 1990s prompted listing winter-run Chinook Salmon as endangered under ESA (59 FR 440, January 4, 1994) and the California Endangered Species Act (CESA). Immediately following the listing, the numbers slowly began to increase. Construction of the temperature control device at Shasta Dam in 1999 helped provide the necessary cold water for winter-run Chinook Salmon. Winter-run Chinook Salmon, because they have a single population, have a higher risk to their population from long-term droughts, climate change, and other catastrophic events that affect flow and water temperature in the Sacramento River.

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 Salmon, but winter-run Chinook Salmon 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 Salmon from other Sacramento River Chinook Salmon runs and from all other populations within the range of Chinook Salmon (DFG 1985, 1998b).

Adults migrate upstream past the RBPP beginning in mid-December and continue into early August, with most passing between January and May, peaking in mid-March (DFG 1985). Winter-run Chinook Salmon spawn only in the Sacramento River, almost exclusively above RBPP, with the majority spawning upstream from Balls Ferry, based on aerial redd survey data. 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 (USFWS and Reclamation 2008). They spawn from 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 RBPP may begin in late July, generally peaks in September, and can continue until mid-March in drier years (Vogel and Marine 1991). The majority of winter-run Chinook Salmon outmigrate past RBPP as fry (Martin et al. 2001) and rear in the Sacramento River downstream before outmigrating to the Delta primarily in December through April. Between 44 and 81 percent (mean 65 percent) of juvenile winter-run Chinook Salmon used areas downstream of RBPP for rearing habitat, and the relative usage of rearing habitat upstream and downstream of RBPP 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).

Central Valley Spring-Run Chinook Salmon On September 16, 1999, the Central Valley spring-run Chinook Salmon ESU was listed as threatened under the ESA by NMFS. The Central Valley spring-run Chinook Salmon ESU includes all naturally-spawned populations of spring-run Chinook Salmon in the Sacramento River and its tributaries, as well as artificially propagated Feather River spring-run Chinook Salmon (70 FR 37177). Naturally-spawning populations of spring-run Chinook Salmon currently are restricted to accessible reaches of the upper Sacramento River; Antelope, Battle, Beegum, Big Chico, Butte, Clear, Deer, and Mill Creeks; and the Feather and Yuba Rivers (DFG 1998b).

Spring-run Chinook Salmon display both stream-type and ocean-type life history strategies. Adults migrate upstream while sexually immature, hold in deep cold pools over the summer, and spawn in late summer and early fall. Juvenile outmigration is highly variable, with some juveniles outmigrating in winter and spring (ocean-type), and others oversummering and then emigrating as yearlings (stream-type).

Adult spring-run Chinook Salmon begin their upstream migation in late January and early February, and continue to their natal streams through June. They hold in cool, deep pools until they spawn in late August to October. Egg incubation continues through March, depending on water temperatures.

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 the young-of-year (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). 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 2009).

Central Valley Fall-/Late Fall-run Chinook Salmon On March 9, 1998 (63 FR 11481), NMFS issued a proposed rule to list fall-run Chinook Salmon as threatened, but determined the species did not warrant listing, and identified it as a candidate species (64 FR 50393). It was then changed to a species of concern in 2004. NMFS also determined that both late fall-run and fall-run comprise a single ESU, but because they are separate in timing and effects, they are distinguished separately for the purposes of this document.

Fall-run Chinook Salmon are the most abundant and widely distributed of the Chinook Salmon runs in the Central Valley, occurring in nearly all anadromous salmonid bearing rivers and streams in the Sacramento and San Joaquin River systems. Historically, the summer water temperature regime in the Sacramento River was a key variable that influenced the life-history timing and strategy of the different salmonids that occur in the basin. Fall-run Chinook Salmon avoid stressful summer conditions by migrating upstream in the fall (September to November) when both air and water temperatures begin to cool. Because they arrive at spawning grounds with fully developed gonads, adult fall-run can spawn immediately (October to November), which allows their progeny to emerge in time to emigrate from the Sacramento River as fry in the subsequent spring (February to May) before water temperatures become too high.

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 freshwater.

Adult fall-run Chinook Salmon migrate into the Sacramento River and its tributaries from June through December in mature condition, with upstream migration peaking in September and

October. Adults spawn soon after arriving at their spawning grounds between late September and December, with peak spawning activity in late October and early November.

Adult late fall-run Chinook Salmon migrate up the Sacramento River between mid-October and mid-April, with peak migration occurring in December (Reclamation 1991). Adults spawn soon after reaching spawning areas between January and April. Fisher reports that peak spawning in the Sacramento River occurs in early February (1994), but carcass surveys conducted in the late 1990s suggest that peak spawning may occur in January (Snider et al. 1998, 1999, 2000).

Fall-run and late fall-run Chinook Salmon are generally able to spawn in deeper water with higher velocities than Chinook Salmon in other runs because of their larger size (Healey 1991). Late fall-run salmon tend to be the largest individuals of the Chinook Salmon species that occur in the Sacramento River basin (USFWS 1996).

Fall-run Chinook Salmon fry emergence occurs from December through March, and fry rear in freshwater for only a few months before migrating downstream to the ocean as smolts between March and July (Yoshiyama et al. 1998). Late fall-run fry emerge from redds between April and June (Vogel and Marine 1991).

Fall-run Chinook Salmon in the Sacramento River generally exhibit two rearing strategies: migrating to the lower reaches of the river or Delta as fry, or remaining to rear in the gravel-bedded reach for about 3 months and then smolting and outmigrating. The highest abundances of fry in the Delta are observed in wet years (Brandes and McLain 2001). Fall-run Chinook Salmon fry rear during a time and in a location where floodplain inundation is most likely to occur, thereby expanding the amount of rearing habitat available. Relative survival of fry appears to be higher in the upper Sacramento River than in the Bay-Delta, especially in wet years (Brandes and McClain 2001).

Water temperatures in the lower Sacramento River are often too high in May and June to support late fall-run Chinook Salmon fry survival, so later-emerging fry that migrate downstream likely suffer high rates of mortality and contribute little to the population. This suggests that a significant fraction of late fall-run juveniles rear in the upper Sacramento River throughout the summer before emigrating in the following fall and early winter as large subyearlings (Fisher 1994). Summer rearing is made possible by the cold water releases from the Shasta-Trinity divisions of the CVP. Late fall-run juveniles generally leave the Sacramento River by December (Vogel and Marine 1991), with peak emigration of smolts in October.

Central Valley Steelhead NMFS listed the Central Valley Steelhead ESU as threatened in 1998 (63 FR 13347). In 2004, NMFS proposed that all west coast steelhead ESUs be reclassified to DPSs and proposed to retain Central Valley Steelhead as threatened. In January 2006, after a status review (Good et al. 2005), NMFS issued its final decision to retain the status of Central Valley Steelhead as threatened (71 FR 834). 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).

Steelhead generally exhibit a more flexible life-history strategy than Chinook Salmon, and the habitat requirements of juvenile steelhead differ from those of juvenile Chinook Salmon. Unlike Chinook Salmon, steelhead can be iteroparous—that is, they can survive spawning, return to the ocean, and migrate into fresh water to spawn again. Post-spawning adults are known as kelts. In general, there are two types of steelhead: winter steelhead and summer steelhead. Winter steelhead are of the ocean-maturing reproductive ecotype, becoming sexually mature during their ocean phase and spawning soon after their arrival at the spawning grounds. Adult summer steelhead are of the stream-maturing type, which enter their natal streams and spend several months holding and maturing in fresh water before spawning. Central Valley Steelhead are predominantly winter steelhead, and this section describes the life history and habitat requirements of winter steelhead.

Central Valley steelhead generally leave the ocean and migrate upstream from August through March (Busby et al. 1996), In the Sacramento River, steelhead migrate upstream nearly every month of the year, with the bulk of migration from August through November and the peak in late September (Bailey 1954, Hallock et al. 1961, McEwan 2001). Spawning in the upper Sacramento River generally occurs from December through April (Newton and Stafford 2011).

Spawning typically begins in December and continues through early March. Peak spawning occurs from late January to early February. Embryos of various state of development are in the spawning gravel from December through April.

Unlike salmon, steelhead may live to spawn more than once and generally rear in freshwater streams for 1 to 3 years before outmigrating to the ocean. Most returning adults in the Central Valley spent 2 years in freshwater before emigrating. For steelhead, 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 2009). Juvenile emigration from the upper Sacramento River occurs between November and late June, with a peak between early January and late March (Reclamation 2008).

Southern DPS of the North American 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 RBPP (Reclamation 2008a, Poytress et al. 2015). 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 (between Jellys Ferry and Bend Bridge) and possibly up to the Cow Creek confluence (Brown 2007, Poytress et al. 2015). 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 (Beamesderfer et al. 2004, Seesholtz et al. 2014, Poytress et al. 2015). 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 and YOY Green Sturgeon have been observed at Red Bluff and the GCID intake (Beamesderfer et al.

2004, Poytress et al. 2015). Adult Green Sturgeon that migrate upstream in April, May, and June are completely blocked by the ACID diversion dam (74 FR 52300), 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). Eggs have been observed upstream from the RBPP (Poytress et al., 2015), and larval Green Sturgeon have been captured during their dispersal stage at about 2 weeks of age (24 to 34 mm fork length) in rotary screw traps at RBPP (DFG 2002) 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 2002, Poytress et al. 2015). 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). 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.

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).

Sacramento River 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 2001). After entry into the Delta, the juveniles remain and rear in the Delta until they are 5 to 10 months of age (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 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 2009).

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 2009).

Central Valley 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 (Naughton et al. 2005, Cooke et al. 2006). 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 2009). 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. 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.

YOY spring-run Chinook Salmon presence in the Delta peaks during April and May, as suggested by the recoveries of Chinook Salmon of a size consistent with the predicted size of spring-run fish at that time of year in the CVP and SWP salvage operations and the Chipps Island trawls. 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 2009). 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.

Central Valley 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.

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 freshwater and outmigrate as yearling smolts the following November through April. Late fall-run fry rear in freshwater from April through the following April. and outmigrate as smolts from October through February (Snider and Titus 2000a, b, and c).

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.

Central Valley 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 2009). 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.

Juvenile steelhead can be found in all waterways of the Delta, but particularly in the main channels leading from their natal river systems (NMFS 2009). 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).

Southern DPS of the North American Green Sturgeon Adult Green Sturgeon move through the Delta from February through April, arriving at holding and spawning locations in 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 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 for 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).

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.

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.

Delta Smelt Delta Smelt was Federally listed as threatened (58 FR 12854, March 5, 1993). Recent monitoring results indicate that the Delta Smelt population continues to remain at an all-time low. In 2006, the USFWS was petitioned to upgrade the status of Delta Smelt to endangered. In 2010 and 2015, the USFWS conducted their 5-year review and found Delta Smelt warranted the upgrade in status, however, the listing was precluded by other higher priority-listing actions. The status of Delta Smelt under CESA was upgraded to endangered in January 2010 (DFG 2011).

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 (58 FR 12854, March 5 1993). 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. 2007). 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 (Baxter et al. 2010, Rose et al. 2013a, b, Sommer and Mejia 2013).

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. Fewer than 10 Delta Smelt were collected in surveys in 2014; the 2014 Delta Smelt index was 9, making it the lowest in Fall Midwater Trawl Survey (FMWT) history (Smelt Working Group 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).

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 freshwater, 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).

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 and 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).

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 Rivers' channels (Kimmerer 2008, Grimaldo et al. 2009, Baxter et al. 2010).

Longfin Smelt Longfin Smelt is a State-listed threatened species throughout its range in California (DFG 2009). USFWS denied a petition for Federal listing because the population in California (and specifically the San Francisco Bay) was not believed to be sufficiently genetically isolated from other populations (74 FR 16169). The Center for Biological Diversity challenged the merits of this determination. In 2011, USFWS entered into a settlement agreement with the Center for Biological Diversity and agreed to conduct a rangewide status review and prepare a 12-month finding to be published by September 30, 2011. After completing the 12-month findings, USFWS determined that listing the Longfin Smelt rangewide was not warranted at the time, but that listing the Bay-Delta DPS of Longfin Smelt was warranted. This was, however, precluded by other higher-priority listing actions (77 FR 19756).

Longfin Smelt are anadromous and spawn in freshwater 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 2009). Spawning in the Sacramento River is believed to occur from just downstream of its confluence with the San Joaquin River 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 2009).

Longfin Smelt larvae are most abundant in the water column usually from January through April (Reclamation 2008a). In the Bay-Delta, 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).

The abundance of Longfin Smelt in the estuary has fluctuated over time but has exhibited statistically-significant declines around 1989 to 1991 and in 2004 (Thomson et al. 2010). Increased Delta outflow in winter and spring is the largest factor possibly affecting Longfin Smelt abundance (77 FR 19756).

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, Kimmerer 2004, Kimmerer et al. 2009).

Entrainment of Longfin Smelt in CVP and SWP export facilities 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.

Impact Analysis

Potential Mechanisms for Change in Fisheries and Analytical Methods

The impact analysis considers changes in the ecological attributes that affect fish and aquatic resources related to changes in flows in the lower Klamath River and CVP operations under the alternatives as compared to the No Action Alternative. Most evaluations are based on water year type. The Trinity water year classification system is used for locations in the Lower Klamath and Trinity River Region. Locations in the Central Valley and Bay-Delta Region use the Sacramento water year classification system.

Changes in Fish Habitat in CVP and SWP Reservoirs

Changes in CVP 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, and Folsom Lake). 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. Because no changes occur in the San Joaquin reservoirs, they are not evaluated in this EIS.

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

Changes in CVP 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 black bass (e.g., Largemouth and Spotted Bass) and catfish.

Reservoir surface water elevations from the CalSim II model were used to analyze potential effects on black bass species (Largemouth, Smallmouth, and Spotted Bass). 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 black bass nests, based upon a relationship between 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 drawdown 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 <0.09 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). Many self-sustaining black bass populations in North America experience nest success (i.e., the nest produces swim-up fry) rates of 21 to 96 percent, with reported survival rates in the 40 to 60 percent range (Hunt and Annett 2002). 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.

Changes in CVP and SWP Reservoir Storage Volume To evaluate changes in operation, changes in reservoir storage were estimated based upon modeled monthly average storage and reservoir elevation output from CalSim II under the operations defined for each alternative, as described in the Analytical Tools Technical Appendix. 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 reservoirs.

The effects analysis in Chapter 4, "Surface Water Supply and Management," 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 are presented as average monthly storage by water year type. Although aquatic habitat within the CVP 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.

Changes in Fish Habitat Conditions in Rivers Downstream from CVP and SWP Reservoirs

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

The portions of the Sacramento River, Trinity River, and lower Klamath River that could be affected by the proposed action alternatives are part of designated critical habitats for the fish species listed under the ESA inhabiting these rivers, as well as being recognized as providing EFH for Pacific salmon under the Magnuson-Stevens Fishery Conservation and Management Act. The effects on habitat for each of these Federally-listed fish species inhabiting the Sacramento, Trinity and Klamath Rivers described in the following sections, applies to the effects of the proposed action alternatives on designated critical habitat for the Federally-listed fish species, and on EFH for Pacific salmon in each of these rivers.

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 can also influence the frequency and duration of inundated floodplains (e.g., Yolo Bypass) that support salmonid rearing and conditions for other native fish species.

The effects analysis in Chapter 4, "Surface Water Supply and Management," 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 are presented as both average monthly flows by month and

water year type to allow examination of the entire range of simulation results for each of the alternatives, as a means of evaluating differences among alternatives. The CalSim II model uses a monthly time step, and it was determined that incremental changes of 5 percent or less were within the range of uncertainty 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.

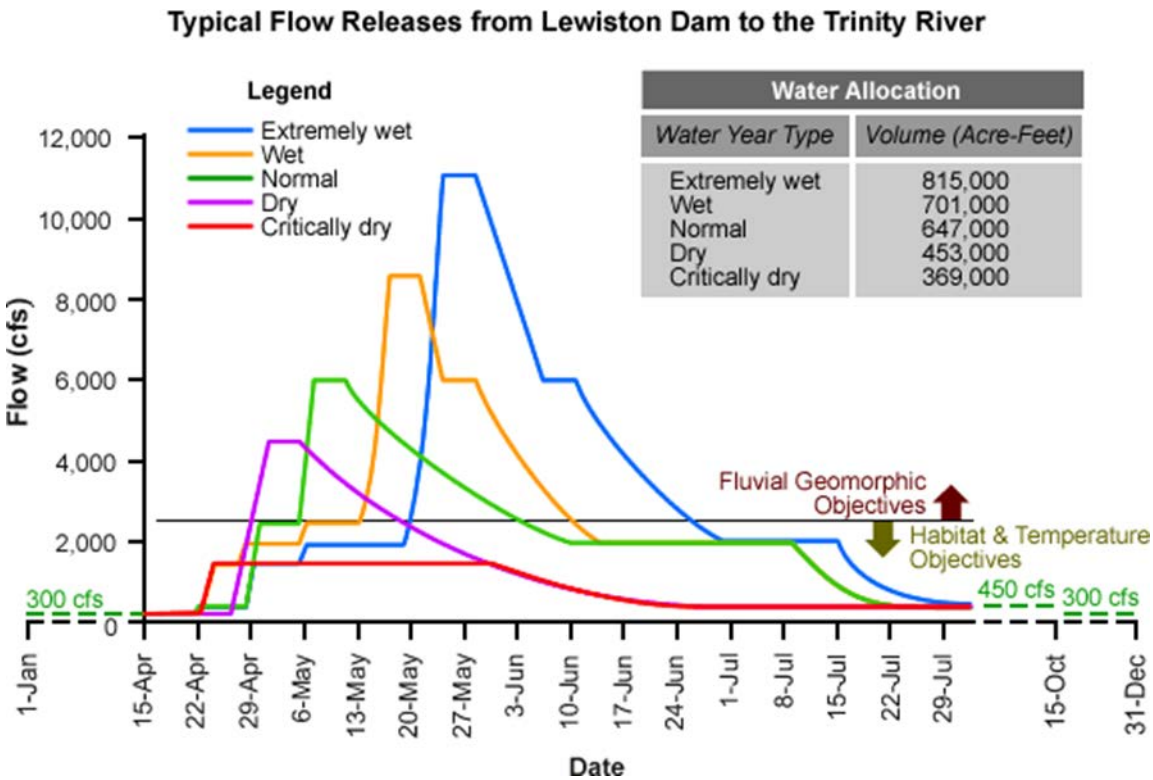
Comparison of Flow-Habitat Relationships To compare the operational flow regime and evaluate the potential effects on habitat for anadromous species inhabiting streams, it was necessary to determine the relationships between streamflow and habitat availability or key flow thresholds affecting habitat attributes for each life stage of these species in the rivers in which flows may be altered by CVP 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 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 longitudinal attributes like water quality, 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 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 in the *Coordinated Long-Term Operation of the Central Valley Project and State Water Project EIS* (Reclamation 2015). Differences between the alternatives and the No Action Alternative are used to identify the effects of each alternative on habitat availability (WUA) for each species and life stage in each river.

Comparison to the Trinity River Functional Flow-Habitat Criteria Because CalSim II produces flows on a monthly time step, the model outputs were downscaled to a daily time step (simulated or approximated hydrology) for use in HEC-5Q and RBM 10 water quality and temperature models. These approximated daily flow patterns were also used to compare the two alternatives and the No Action Alternative operational scenarios for the frequencies of flow levels associated with functional flow criteria specified for the Trinity River fishery restoration program (Figure 7-1). Flow exceedance plots—for specific time periods when operations of the alternatives may differ from the No Action Alternative—are used to compare the performance of the alternatives and No Action Alternative relative to functional flow-habitat criteria. The late-summer (August to September) and late-spring (May to June) months are the seasonal periods when flow patterns in the Trinity River could be altered to conduct the proposed action under either of the alternatives. Accordingly, recommended Lewiston Dam release levels, intended hydrographic

patterns, management targets and biological purposes—adopted by the *Trinity River Mainstem Fishery Restoration Final EIS/Environmental Impact Report Record of Decision* (ROD) (DOI and Hoopa Valley Tribe 2000) during select seasons (see Table 7-2)—were compared to projected flow releases from Lewiston Dam (for the alternatives and the No Action Alternative) during those periods when the releases for the proposed action alternatives could deviate from these criteria.



Source: http://www.trrp.net/ restore/flows/typical/

Note: Water allocations are those specified in the 2000 Record of Decision for the Trinity River Mainstem Fishery Restoration Program (DOI and Hoopa Valley Tribe 2000)

Figure 7-1. Fishery Restoration Seasonal Flow Release Patterns from Lewiston Dam for the Five Trinity Basin Water Year Types, Showing Functional Flow Objective Levels

Table 7-2. Excerpts From the Recommended Lewiston Dam Releases, Management Targets, Purposes, and Benefits, for Seasonal Periods Potentially Affected by the Proposed Action Alternatives

Seasonal Period	Release (cfs)	Hydrograph Component	Management Target	Purpose	Intended Benefit
Extremely Wet					
Jun 10-Jun 30	6,000 to 2,000	Descending limb	Descent rate to mimic pre-TRD	Inundate point bar Minimize river stage change to preserve egg masses of yellow-legged frogs Maintain seasonally variable water surface in side channels and off-channel wetlands	Prevent riparian vegetation initiation along low water channel margins Reduce fine sediment (<5/16 inch) storage within surface channelbed Improve juvenile salmonid growth Increase riparian vegetation and future LWD recruitment
Wet					
May 28-Jun14	6,000 to 2,000	Descending limb	Descent rate to mimic pre-TRD Descent rate < 0.1 ft/day	Inundate point bars Minimize river stage change to preserve egg masses of yellow-legged frogs Maintain seasonally variable water surface in side channels and off-channel wetlands	Prevent riparian vegetation initiation along low water channel margins Reduce fine sediment (<5/16 inch) storage within surface channelbed Improve juvenile salmonid growth
Normal					
May 11-Jun10	6,000 to 2,000	Descending limb	Descent rate to mimic pre-TRD Descent rate < 0.1 ft/day	Inundate point bars Minimize river stage change to preserve egg masses of yellow-legged frogs Maintain seasonally variable water surface in side channels and off-channel wetlands	Reduce fine sediment (<5/16 inch) storage within surface channelbed Improve juvenile salmonid growth Increase riparian vegetation and future LWD recruitment

Table 7-2. Excerpts From the Recommended Lewiston Dam Releases, Management Targets, Purposes, and Benefits, for Seasonal Periods Potentially Affected by the Proposed Action Alternatives (contd.)

Seasonal Period	Release (cfs)	Hydrograph Component	Management Target	Purpose	Intended Benefit
Dry					
May 5 - Jun 26	4,500 to 450	Descending limb		Inundate point bars Minimize river stage change to preserve egg masses of yellow-legged frogs Maintain seasonally variable water surface in side channels and off-channel wetlands Improve salmonid smolt production by providing temperatures necessary for survival of steelhead, Coho Salmon, and Chinook Salmon smolts	Prevent riparian initiation along channel margins Reduce fine sediment (<5/16 inch) storage within surface channelbed Improve juvenile Chinook Salmon growth Increase survival of steelhead fry Provide outmigration cues for Chinook Salmon smolts
Critically Dry					
May 29-Jun 26	1,500 to 450	Descending limb	Descent rate to mimic pre-TRD Provide non-lethal water temperatures to Weitchpec for Coho Salmon smolts (≤ 62.6°F) until June 4, and for Chinook Salmon smolts (≤ 68°F) until mid-June	Minimize river stage change to preserve egg masses of yellow-legged frogs Inundate point bars Improve salmonid smolt production by providing temperatuers necessary for survival of steelhead, Coho Salmon, and Chinook Salmon smolts	Prevent riparian initiation along low water channel margins Reduce fine sediment (<5/16 inch) storage within surface channelbed Maintain seasonal variable water levels in side channel and off-channel wetlands Sustain juvenile salmonid smolt production Provide outmigration cues for Chinook Salmon smolts

Table 7-2. Excerpts From the Recommended Lewiston Dam Releases, Management Targets, Purposes, and Benefits, for Seasonal Periods Potentially Affected by the Proposed Action Alternatives (contd.)

Seasonal Period	Release (cfs)	Hydrograph Component	Management Target	Purpose	Intended Benefit
All Water Year Types					
Jul 22-Sept 30	450	Summer baseflow	Provide water temperatures ≤ 60°F to Douglas City through Sept 14 Provide water tempertures ≤ 56°F to Douglas City from Sept 15 through Sept 30	Increase survival of holding adult spring-run Chinook Salmon by providing optimal thermal refugia	Increase production of Coho Salmon and steelhead by providing water temperatures conducive to growth

Key:
°F = degrees Fahrenheit
< = less than
cfs = cubic feet per second
LWD = large woody debris
TRD = Trinity River Division

Changes in Water Temperatures Water temperatures in the rivers and streams downstream of the CVP reservoirs are influenced by factors such as reservoir cold water pools, 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 water releases from the reservoir. During this time of year, ambient air temperatures contribute substantially to warming instream flows downstream of reservoirs. 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 three approaches: (1) a comparison of average monthly water temperatures between the alternatives and the No Action Alternative, (2) a comparison of average monthly water temperatures to established temperature objectives intended to be protective of fish, and (3) a comparison of daily average water temperature statistics for the Trinity and lower Klamath Rivers to established temperature objectives and biologically-relevant temperature criteria for various key periods between the alternatives and the No Action Alternative. 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. 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 5, "Surface Water Quality," includes a summary of the average monthly water temperature in each major stream downstream of CVP reservoirs. 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 No Action Alternative. 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 time step. Therefore, the analysis is based on monthly average temperature results for all water years and by water year type (as defined in Chapter 4, "Surface Water Supply and Management"). For this monthly analysis that uses two cascading models, 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 of Daily Water Temperature Statistics for the Trinity River and Lower Klamath River This analysis is based on the one-dimensional daily averaged water-temperature outputs from the RBM 10 water temperature models for the Trinity and Klamath Rivers, the analytic procedures for which are described in Chapter 5, "Surface Water Quality," and in the Analytical Tools Technical Appendix. These water-temperature models were used to simulate the daily average temperatures (DAT) along the Trinity River below Lewiston Dam and in the lower Klamath River below the Trinity River confluence for the two action alternatives and No Action Alternative operational scenarios for a hydrologically representative 24-year period (1980 to 2003). Seven day moving averages of daily maximum (7DADM) temperatures were also estimated for some analyses based on a statistical derivation of 95 percentile exceedance probabilities of daily fluctuations in water temperature at Lewiston Dam (see the Analytical Tools Technical Appendix for details on computation of estimated 7DADM temperature values). Descriptive statistics for daily water temperatures were compiled for several locations along the Trinity and Klamath Rivers, over the course of key biologically-relevant periods, to compare the ability of operations considered under the alternatives to meet water temperature objectives and temperature management criteria for various fish species.

Comparison to Established Water Temperature Thresholds The average monthly water temperature output from CalSim II does not have the resolution to allow a direct comparison to the average daily temperature objectives identified in Table 7.3. Nonetheless, the average monthly water temperatures provide the basis for a coarse evaluation of the likelihood that temperature objectives (Table 7-3) would be exceeded. These objectives are used as thresholds in the temperature exceedance analysis where the frequency of exceedance (percent of years) is calculated. 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.

Water temperatures in the Feather and American Rivers were not modeled. However, minimal changes in storage and flows under the action alternatives would result in similar water temperatures under the action alternatives relative to the No Action Alternative. Therefore, there was no further evaluation conducted on these system for water temperature thresholds.

Table 7-3. Water Temperature Objectives

Compliance Location	Year Types	Dates	Temperature Objective (°F)[a]	Purpose
Trinity River				
Lewiston Dam to Douglas City[1,2]	All Year Types	July 1 – September 15	< 60	Spring-run Chinook Salmon holding
		September 16 – September 30	≤ 56	Spring-run Chinook Salmon spawning
Lewiston Dam to North Fork Trinity River Confluence[2]	All Year Types	October 1 – December 31	< 56	Spring-run and fall-run Chinook Salmon spawning
Lewiston Dam to Weitchpec[3]	Normal, Wet, Extremely Wet	April 15 – May 22 May 23 – June 4 June 5 – July 9	≤ 55.4 ≤ 59 ≤ 62.6	Salmonid smolt outmigration
	Dry, Critically Dry	April 15 – May 22 May 23 – June 4 June 5 – June 15	≤ 59 ≤ 62.6 ≤ 68	Salmonid smolt outmigration[b]
Clear Creek				
Igo[4]	All Year Types	June 1 – September 15	60	Spring-run Chinook Salmon holding and rearing
		September 15 – October	56	Spring-run and fall-run Chinook Salmon spawning and egg incubation
Sacramento River				
Clear Creek[2] Balls Ferry[2] Jellys Ferry[2]	All Year Types	May – October	56	Winter- and spring-run Chinook Salmon spawning and egg incubation
Bend Bridge[2]	All Year Types	May – October	56	Winter- and spring-run Chinook Salmon spawning and egg incubation
			63	Green Sturgeon spawning, incubation, and rearing
Feather River				
Robinson Riffle[2]	All Year Types	September – April	56	Spring-run Chinook Salmon and steelhead spawning and incubation
		May – August	63	Spring-run Chinook Salmon and steelhead rearing
American River				
Watt Avenue Bridge[2]	All Year Types	May – October	65	Juvenile steelhead rearing

Source:
[1] NCRWQCB 2011
[2] SWRCB Water Rights Order 90-5
[3] DOI and Hoopa Valley 2000; USFWS et al. 2000
[4] NMFS 2009

Notes:
[a] Criteria are daily average temperatures
[b] Facilitate early outmigration by allowing gradual warming toat least marginal temperatures throughout smolt outmigration for juvenile salmonids

Key:
°F = degrees Fahrenheit
< = less than
≤ = less than or equal to

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. Two different models were used to assess changes in salmonid production potential: (1) SALMOD, and (2) the Interactive Object-Oriented Simulation (IOS) model for winter-run Chinook Salmon. In the modeling simulations, in certain critical years, the reservoirs approach *dead-pool volume* when cold water availability is limited. Modeling results likely represent the worst-case conditions in critical years, but do not account for real-time operations.

Comparison of Annual Production Using SALMOD The SALMOD model was used to assess changes in the annual production potential of four runs of Chinook Salmon in the Sacramento River between Keswick Dam and the RBPP (see Analytical Tools Technical Appendix for additional information on SALMOD). 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. SALMOD uses flows and output from the water temperature models that are downscaled from the monthly time step CalSim II model, and differences in production of 5 percent or less were considered to be within the uncertainty of the model processing. Therefore, production estimates within 5 percent or less of each other are considered to be not substantially different, or “similar” in this comparative analysis.

While steelhead are not directly evaluated in SALMOD, effects for late fall-run Chinook Salmon are considered representative for steelhead since NMFS, in their 2009 BO, assumed late fall-run Chinook Salmon could be used as a surrogate for steelhead because they have similar life history stages, including spawning at the same time of the year (NMFS 2009).

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 (see Analytical Tools Technical Appendix for additional information on IOS). 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 average annual escapement and the average escapement by water year type over the 82-year CalSim II simulation period. The IOS model also provides survival at various life stages and locations, including eggs, fry-to-smolt, smolt production, smolts between RBPP and the Delta, and smolts in the Delta. The IOS model uses scenario-specific daily DSM2, CalSim II, and Sacramento River Basin Water Temperature Model (HEC-5Q) data as model input. IOS uses output from the monthly time step CalSim II model or other models downscaled from CalSim II

as input, and differences in production of 5 percent or less were considered to be within the uncertainty of 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.

Changes in Fish Habitat Conditions in the Bay-Delta

Changes in CVP operations under the alternatives would affect the Bay-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.

Changes in Delta Hydrodynamics Operations of the CVP 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 Delta channels that can alter fish movement patterns (Moyle and Bennett 2008).

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 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. 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, altering predation success.

Old and Middle River (OMR) reverse flows occur as the rate of water diverted at the CVP and SWP export facilities exceeds tidal and downstream flows within the central region of the Delta. These reverse flows have been identified as a potential cause of fish mortality at the CVP and SWP fish facilities (USFWS 2008, Mount et al. 2012). The most biologically sensitive period when the effects of reverse flows could affect multiple Delta species, including Chinook Salmon and Delta Smelt, extends from late winter through early summer (December through June) (USFWS 2008, Zeug and Cavallo 2014). Changes in OMR flows to exceed -5,000 are used as an indicator of project effects.[5]

Changes in CVP operations can affect through-Delta survival of migratory (e.g., salmonids) and resident (e.g., Delta Smelt and Longfin Smelt) fish species through changes in the level of entrainment at CVP export pumping facilities (USFWS 2008, Zeug and Cavallo 2014). The south Delta CVP facilities are the largest water diversions in the Delta and in the past, have entrained large numbers of Delta fish species. Tides, salinity, turbidity, freshwater inflow to the Delta, 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

[5] Results of analyses of the relationship between the magnitude of reverse flows in OMR and salvage of adult Delta Smelt in the late winter shows a substantial increase in salvage as reverse flows increase (i.e., become more negative), and exceed approximately -5,000 cfs.

passage success and survival. Entrainment risk for fish also tends to increase with increased reverse flows in Old and Middle Rivers.

Larvae and early juvenile Delta Smelt are most prevalent in the Delta in the spring months of March through June. Evaluation of changes in the Delta hydrodymanics, such as changes in exports, Delta outflow, and OMR reverse flows were used to characterize potentical changes in entrainment.

Changes in X2 Location Changes in CVP operations under the alternatives could change the location of Fall X2 position (in September through December). The predicted location of Fall X2 position (in September through December) is used as an indicator of the 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 kilometers (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.

To evaluate 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 to December, and compared for differences. There are uncertainties and limitations associated with this approach. For example, 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. 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.

Evaluation of Alternatives

The impact analysis in this EIS is based upon the comparison of the alternatives to the No Action Alternative projected in the year 2030.

No Action Alternative

Under the No Action Alternative, fisheries resources would be comparable to the conditions described in the *Affected Environment* section of this chapter. Conditions in 2030 would be different than existing conditions primarily due to climate change and sea-level rise, general plan development throughout California, and implementation of reasonable and foreseeable water resource 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. For unregulated rivers, reduced snowpack would shift flow patterns to an earlier and shorter spring runoff period. For regulated rivers, reservoirs would be full more frequently by the end of April or May by the year 2030 than they would be 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 result in reduced flows and

increased water temperatures in the summer and early fall. These conditions would occur for all reservoirs in the California foothills and mountains, including non-CVP and non-SWP reservoirs. In addition, average air temperatures are expected to increase, further contributing to warmer water temperatures in rivers during summer and fall.

Klamath and Trinity River Watershed

Trinity River Watershed Under the No Action Alternative, Reclamation would not release additional flows from Lewiston Dam in August and September as a measure to reduce the potential and severity of fish disease outbreaks that could lead to large-scale pre-spawning mortality of adult anadromous salmonids. Late-summer releases from Lewiston Dam would remain at 450 cfs, as prescribed in the Trinity River ROD (DOI and Hoopa Valley Tribe 2000). Accordingly, no changes, other than those associated with climate change, would be expected to occur in 1) the annual patterns of Trinity Lake water storage and surface elevation fluctuations, 2) late-summer flow and water temperature patterns in the Trinity River below Lewiston Dam, and 3) spring-summer flow and water temperature patterns in the Trinity River, all of which could affect fish and other aquatic resources within the Trinity River watershed.

The ongoing implementation of the Trinity River Restoration Program (TRRP) would be expected to continue to pursue long-term improvements to habitat conditions for anadromous salmonids and resident native freshwater fish, other aquatic organisms, and riverine and riparian-dependent wildlife and plant species. It is anticipated that these continuing restoration activities in tandem with the variable annual flow releases from Lewiston Dam on the Trinity River will increase floodplain connectivity, reactivate channel migration across floodplains (especially within rehabilitation sites), and improve riparian and aquatic habitat diversity and quality for anadromous salmonids and riparian-dependent species throughout the Trinity River, from Lewiston Dam to the Klamath River confluence.

Although the potential risk, frequency, and magnitude of future fish die-offs occurring in the lower Klamath River during the late-summer under the No Action Alternative cannot be predicted with certainty, at this time, it is currently thought that low flows and warm water temperatures in the lower Klamath River—combined with high densities of adult salmon and steelhead in the river during August and September—contributes to the risk of disease outbreaks that could cause large-scale mortality of salmon (DFG 2004, Strange 2010a and 2015, USFWS and NMFS 2013). It is more certain that a large level of pre-spawning salmon mortality can potentially have a disproportionate effect on sub-basin stocks, which, in fact, occurred for Trinity River Hatchery fall-run Chinook Salmon in the 2002 event (DFG 2004). High levels of pre-spawning mortality, including that caused by disease epizootics, can affect salmon reproduction levels and, consequently, the age-class structure of subsequent generations for a number of years beyond the year in which the mortality event occurs. Any disproportionate effects of future fish die-offs, from any cause, on Trinity River salmon stocks would impact natural and hatchery spawning escapement goals for the TRRP, as well as commercial, sport, and tribal harvest allocations.

Lower Klamath River from Trinity River to the Pacific Ocean Fishery conditions in the lower Klamath River, downstream from the Trinty River confluence, under the No Action Alternative are the same as the description of fish management and habitat conditions and the status of key fish species provided in the *Affected Environment* section. Under the No Action Alternative,

Reclamation would not release additional flows from Lewiston Dam in August and September to augment flows in the lower Klamath River as a measure to reduce the potential for and severity of fish disease outbreaks that could lead to large-scale pre-spawning mortality of adult anadromous salmonids. Late-summer flows could continue to periodically fall to levels that were associated with the 2002 fish die-off and to levels reported in more recent Ich infection incidents in 2014 and 2015 (Belchick 2015, USFWS 2015b).

Large-scale fish die-offs, similar to the one that occurred in 2002, were, up to that time, unprecedented in the Klamath River Basin (DFG 2004). Although the proximate causative factor of the 2002 die-off is known, a primary epizootic of the Ich parasite, and secondary infection by the columaris bacterium, and other factors, are thought to contribute to the virulence and outbreaks of Ich infection in the lower Klamath River. The potential frequency for future fish die-offs under the No Action Alternative cannot be predicted with certainty at this time.

The pathogens involved in the 2002 fish die-off are always present in the lower Klamath River, and water temperatures are normally very warm (≥ 70°F) and at optimal levels for high rates of pathogen replication in the late-summer when fall-run Chinook Salmon begin spawning migrations into the river. Therefore, a disease outbreak could occur anytime conditions exist that facilitate pathogen infection and transmissivity. High densities of adult salmon staging in the lower Klamath River for an extended period of time is thought to be an important primary risk factor contributing to Ich disease outbreaks (Guillen 2002, DFG 2004, USFWS and NMFS 2013, USFWS 2015b). High densities of adult salmon staging in the lower Klamath River can result from moderate to large annual run sizes, low river flows that restrict holding habitat areas, and high water temperatures (≥ 73.4°F) that cause a thermal behavioral barrier to migrating adult salmon. Low water velocities are also thought to contribute to the successful transmissivity and infection of host fish by the free-swimming infectious life stage of the Ich parasite (Strange 2015). So, it is thought that in years with higher late-summer river flows (and associated higher water velocities) in the lower Klamath River, transmissivity and infection rates of Ich may be reduced.

Because future salmon run sizes cannot be predicted with certainty, a flow exceedance probability for the months of August and September was used to provide one measure of the potential risk of occurance of disease outbreaks among adult anadromous salmonids in the lower Klamath River under the No Action Alternative. The projected average montly flows under the No Action Alternative—for current and foreseeable future conditions during the late-summer period when adult salmon are susceptible to disease outbreaks that could cause large-scale fish die-offs—could fall to levels associated with the 2002 fish die-off and more recent reported Ich infections (≤ 2,000 cfs) about 4 percent of the time, and to levels below the 2,800 cfs preventative baseflow level of the proposed action alternatives about 21 percent of the time (Figure 7-2).

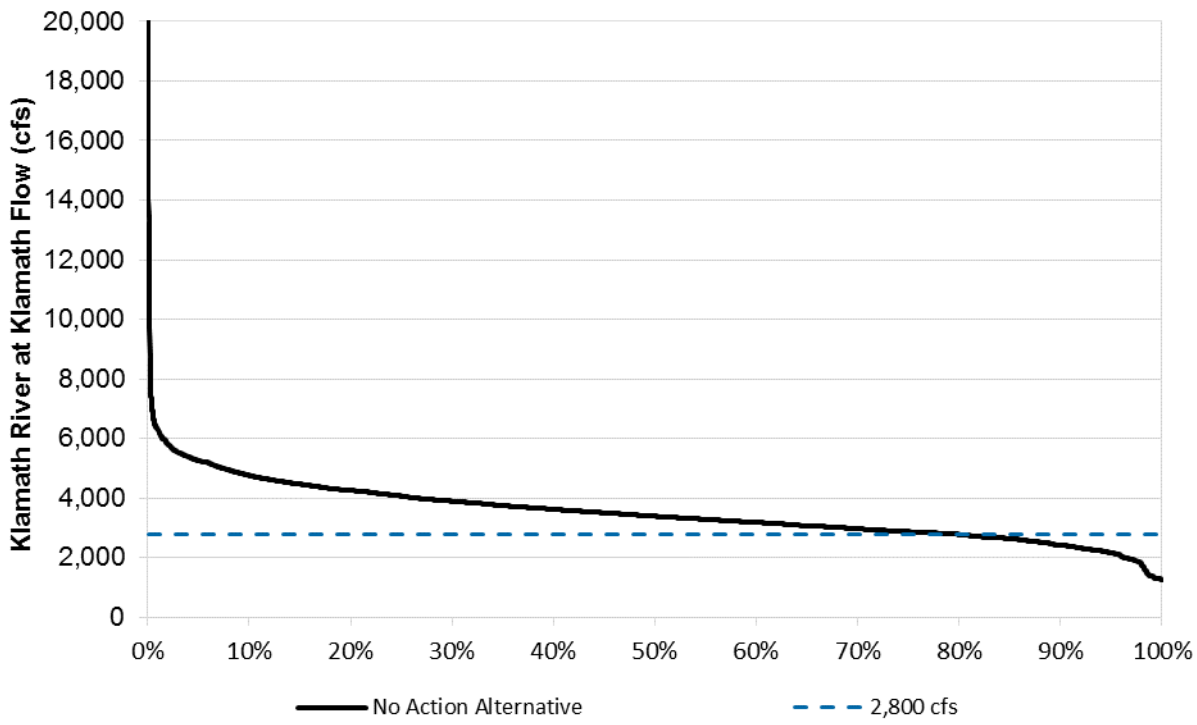


Figure 7-2. August Through September Flow Exceedance Probability for the Klamath River at Klamath, California Under the No Action Alternative

Proposed Action (Alternative 1)

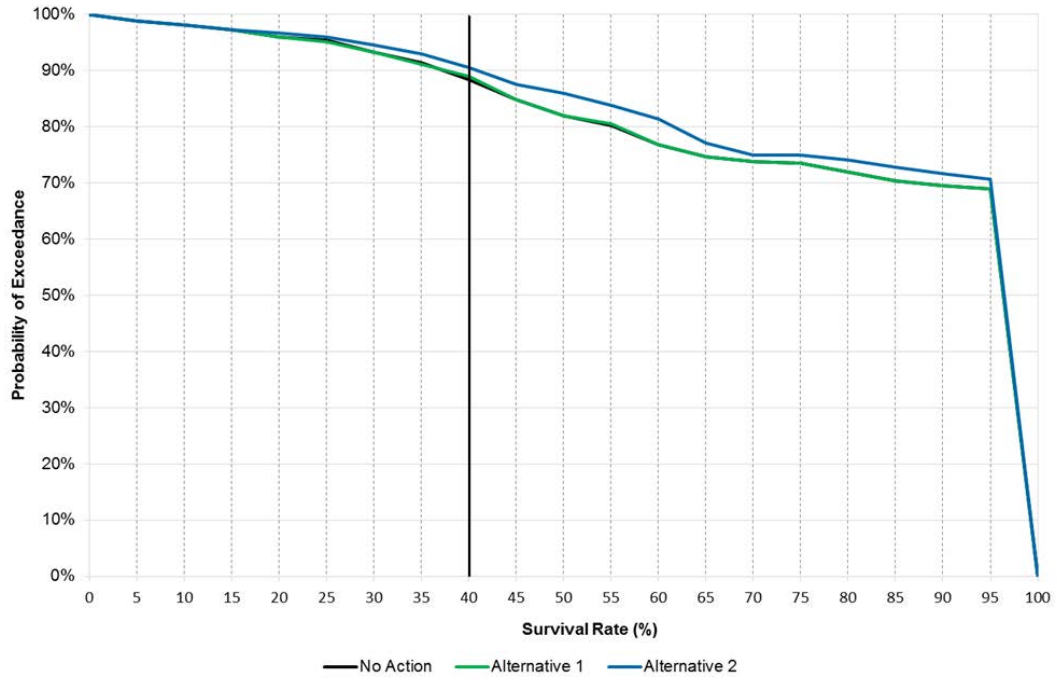
As described in Chapter 3, "Considerations for Describing Affected Environment and Enviromental Consequences," the effects under Alternative 1 are compared to the effects under the No Action Alternative.

Lower Klamath and Trinity River Region

Fish Habitat Conditions in the CVP Reservoir

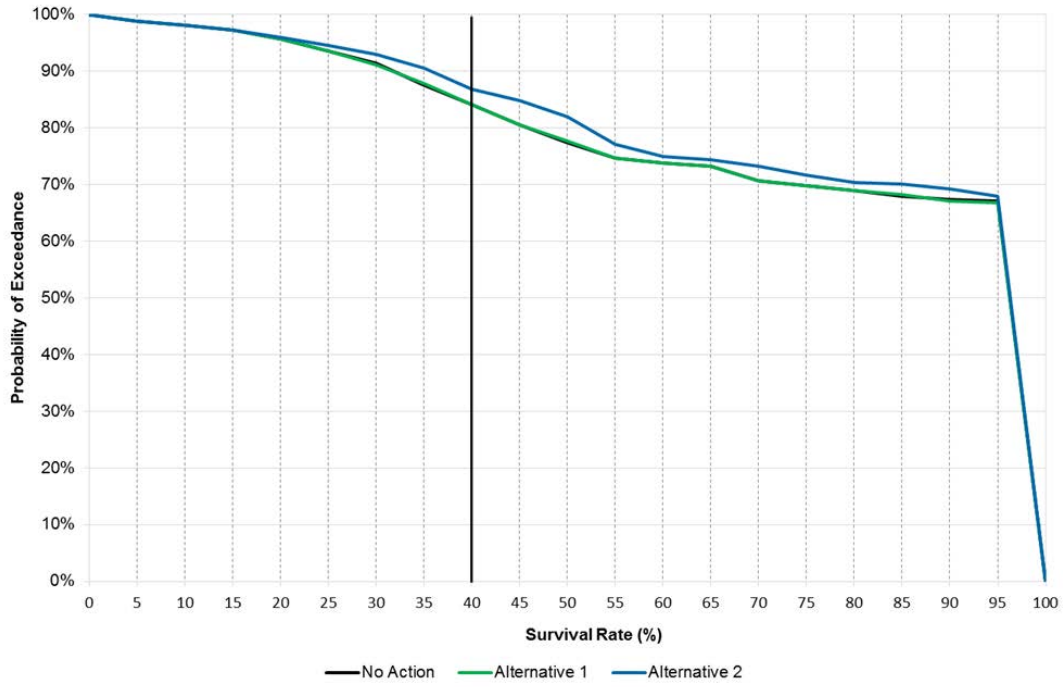
Changes in Black Bass Nesting Success As shown in Figures 7-3 through 7-5, nest survival for all the three black bass species in Trinity Lake would be essentially the same under Alternative 1 as compared to the No Action Alternative, differing by less than 1 percent. Largemouth Bass and Smallmouth Bass would exhibit likelihoods of nest survival of 40 percent or greater nearly 85 to 90 percent of the time. Spotted Bass nesting success would be 40 percent or greater nearly 100 percent of the time under both 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 in Trinity Lake would be similar to those under the No Action Alternative.



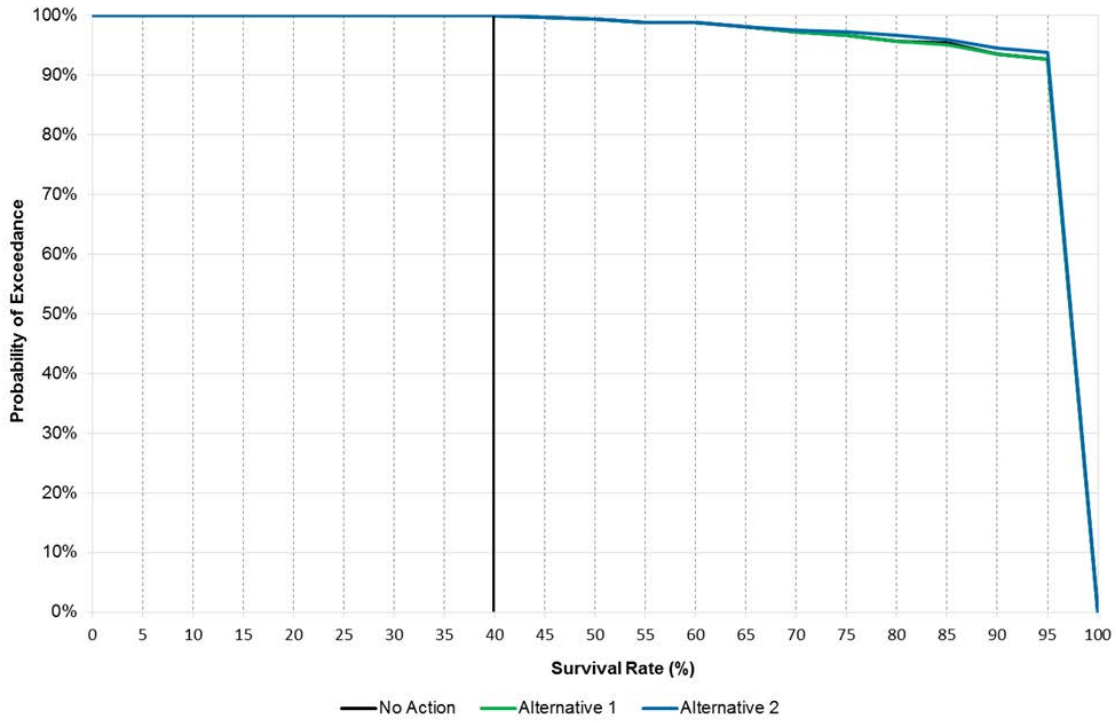
Note: Vertical line indicates typical nest survival rate in California reservoirs.

Figure 7-3. Comparison of Largemouth Bass Nesting Success Probabilities From March Through June in Trinity Lake for the No Action Alternative, Alternative 1 and Alternative 2



Note: Vertical line indicates typical nest survival rate in California reservoirs.

Figure 7-4. Comparison of Smallmouth Bass Nesting Success Probabilities From March Through June in Trinity Lake for the No Action Alternative, Alternative 1 and Alternative 2



Note: Vertical line indicates typical nest survival rate in California reservoirs.

Figure 7-5. Comparison of Spotted Bass Nesting Success Probabilities From March Through June in Trinity Lake for the No Action Alternative, Alternative 1 and Alternative 2

Changes in Cold-Water Fish Habitat The analysis of effects associated with changes in operation to provide additional late-summer flow releases from Lewiston Dam 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 be similar, resulting in lower end-of-year reservoir storage in Trinity Lake, the only CVP storage reservoir in the Klamath-Trinity Basin. End-of-year storage in Trinity Lake would decrease by no more than 4 percent in any water year type (see Chapter 4 "Surface Water Resources and Water Supply"). Trinity Lake storage would decrease by no more than 2 percent in any month of extremely wet water years.

Using Trinity Lake storage as an indicator of habitat available to fish species inhabiting the reservoir, the amount of habitat for reservoir fishes would generally be similar, except in September of dry water years, when storage could differ by 4 percent compared to the No Action Alternative, and most months of extremely wet water years when storage could be 1 to 2 percent less, under Alternative 1 relative to the No Action Alternative.

number of areas in the upper Trinity River where stranding is likely to occur and the conservative ramping rates that would be implemented for the proposed action (Chamberlain 2003)[7], the proportion of rearing juvenile salmonids that may be vulnerable to stranding is anticipated to be small and would not be expected to impact overall production.

Trinity River spring-run Chinook Salmon begin spawning by about the third week in September in most years (USFWS and Hoopa Valley Tribe 1999). However, the timing and down-ramping pattern of late-summer augmentation releases during the third week of September is designed to avoid and minimize effects on spawning spring run salmon. Chamberlain and Hetrick (2013) reported that reduction of flows in September 2013 from 900 cfs to 450 cfs did not dewater up to 65 spring-run Chinook Salmon redds completed through September 19 that year. In the case where an emergency pulse flow action is required at the end of the preventative baseflow period, a small number of spring-run Chinook Salmon that begin to construct redds and spawn during this period may experience a disruption of spawning activites or, in the worst case, completed or partially-completed redds could be dewatered (Gaeuman, pers. com. 2016). However, this effect is expected to be infrequent and minimal.

Pacific Lamprey Adult Pacific Lamprey and River Lamprey immigrate into the Klamath-Trinity River basin tributaries from spring through summer before spawning the following winter and spring. Juvenile lamprey larvae (ammocoetes) rear year-round in the mainstem Trinity River and its tributaries in low-velocity pools and channel margins with a dominant substrate of fine silt, sand, or small gravels (Moyle 2002, USFWS 2010). Increased late-summer augmentation flows may cause increased water velocities and disturbance of fine sediments along the summer baseflow channel where lamprey ammocoetes are living. Because the range of augmentation flows under Alternative 1 would be within the typical range of annual fluctuations in the upper Trinity River, which lampreys experience over their freshwater juvenile life stage, it is expected that juvenile lampreys will redistribute to other areas of suitable habitat over the course of the augmentation flow cycle, if disturbed by higher water velocities.

Changes in Trinity River Water Temperatures during the Late Summer through Fall

Chinook Salmon, Coho Salmon, and Steelhead Potential effects associated with changes in operation to provide additional late-summer flow releases from Lewiston Dam on the water temperature criteria and objectives specified by the Trinity River ROD for anadromous salmonids in the Trinity River downstream of Lewiston Dam were evaluated by examining changes in DAT statistics at key temperature objective/compliance locations during July through December. Consideration of changes in water temperatures through the fall months after completion of the late-summer augmentation releases is important because of the potential latent effect that additional flow releases in August and September may have on reducing cold water storage in Trinity Lake and, therefore, on dam release and river temperatures in subsequent fall months (see Chapter 5, “Surface Water Quality”), and the ability of operations to achieve water temperature compliance objectives and temperature management criteria for spawning salmon. Differences in DAT of 1°F or less are considered to be similar given the typical accuracy and

[7] Chamberlain (2003) reported that stranding potential juvenile salmonids was less at pilot channel restoration sites than at sites with riparian encroachment berms.

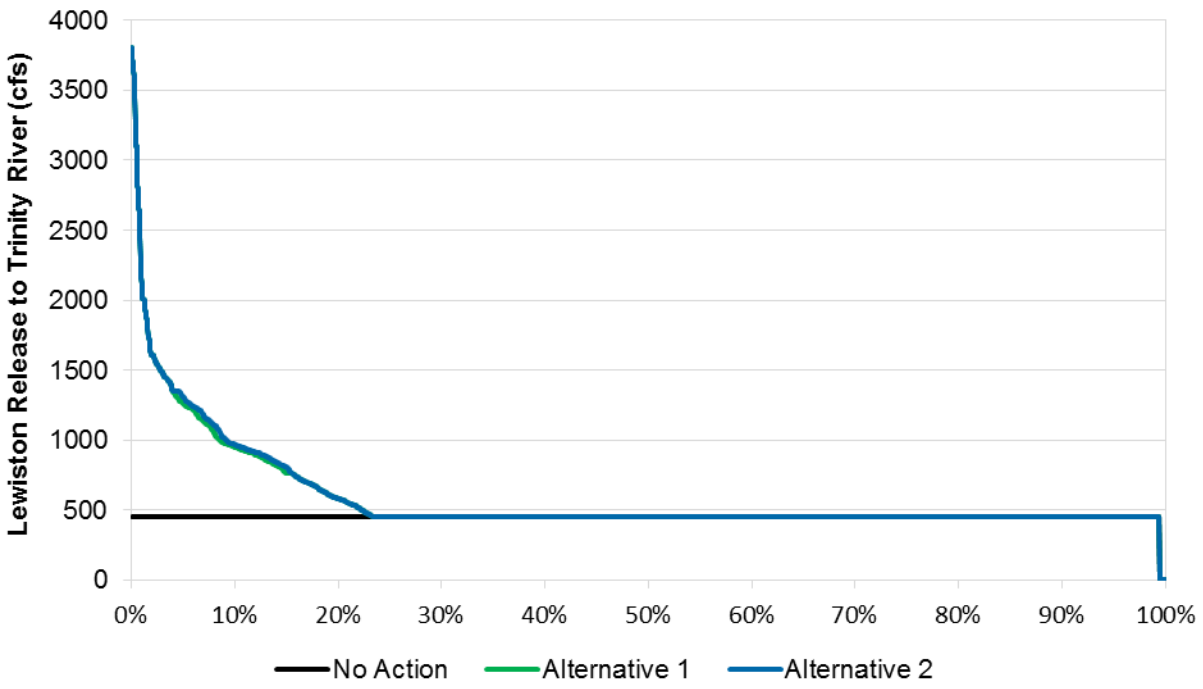


Figure 7-6. Comparison of the Exceedance Probabilities of Predicted Daily Trinity River Flows Below Lewiston Dam for the No Action Alternative, Alternative 1, and Alternative 2

Flow rates less than 1,000 cfs typically would not be expected to overtop berms, many of which have been removed by the Trinity River Restoration Program in the last decade as part of extensive channel rehabilitation projects (Hoopa Valley Tribe et al. 2011, TRRP SAB 2013, TRRP 2014)[6]. Some high-flow side channels and floodplain areas adjacent to the summer baseflow channel, that get inundated by the additional late-summer augmentation release flows, would allow juvenile fish to temporarily distribute along and use these areas for rearing until flows are returned to summer baseflow, when they will move with receding flows back to summer flow channel habitat. However, most juvenile Coho Salmon, Chinook Salmon, and steelhead rearing in the Trinity River during August and September are at a larger parr or pre-smolt size and generally prefer deeper, swifter habitats than fry-sized fish, which would likely minimize numbers of salmon and steelhead parr moving up onto shallower areas inundated at the higher stage extents of augmentation flows.

Flows greater than about 2,000 cfs associated with preventative and emergency pulse flow components of the proposed action alternatives have the potential to minimally affect juvenile Coho Salmon and steelhead rearing in the river in August and September by stranding them in side- and off-channel areas inundated by the high pulse flows once flows are reduced back to the summer baseflow of 450 cfs. Ramping rates for both the ascending and receding flows associated with these pulse flows are designed to minimize public and environmental impacts, including stranding fish. Given that channel rehabilitation over the last decade has reduced the

[6] More than half of the 44 original channel rehabilitation sites (nearly 15 miles of the 40 mile upper Trinity River Restoration reach) have had channel rehabilitation treatments (TRRP SAB 2013; TRRP 2014).

number of areas in the upper Trinity River where stranding is likely to occur and the conservative ramping rates that would be implemented for the proposed action (Chamberlain 2003)[7], the proportion of rearing juvenile salmonids that may be vulnerable to stranding is anticipated to be small and would not be expected to impact overall production.

Trinity River spring-run Chinook Salmon begin spawning by about the third week in September in most years (USFWS and Hoopa Valley Tribe 1999). However, the timing and down-ramping pattern of late-summer augmentation releases during the third week of September is designed to avoid and minimize effects on spawning spring run salmon. Chamberlain and Hetrick (2013) reported that reduction of flows in September 2013 from 900 cfs to 450 cfs did not dewater up to 65 spring-run Chinook Salmon redds completed through September 19 that year. In the case where an emergency pulse flow action is required at the end of the preventative baseflow period, a small number of spring-run Chinook Salmon that begin to construct redds and spawn during this period may experience a disruption of spawning activites or, in the worst case, completed or partially-completed redds could be dewatered (Gaeuman, pers. com. 2016). However, this effect is expected to be infrequent and minimal.

Pacific Lamprey Adult Pacific Lamprey and River Lamprey immigrate into the Klamath-Trinity River basin tributaries from spring through summer before spawning the following winter and spring. Juvenile lamprey larvae (ammocoetes) rear year-round in the mainstem Trinity River and its tributaries in low-velocity pools and channel margins with a dominant substrate of fine silt, sand, or small gravels (Moyle 2002, USFWS 2010). Increased late-summer augmentation flows may cause increased water velocities and disturbance of fine sediments along the summer baseflow channel where lamprey ammocoetes are living. Because the range of augmentation flows under Alternative 1 would be within the typical range of annual fluctuations in the upper Trinity River, which lampreys experience over their freshwater juvenile life stage, it is expected that juvenile lampreys will redistribute to other areas of suitable habitat over the course of the augmentation flow cycle, if disturbed by higher water velocities.

Changes in Trinity River Water Temperatures during the Late Summer through Fall

Chinook Salmon, Coho Salmon, and Steelhead Potential effects associated with changes in operation to provide additional late-summer flow releases from Lewiston Dam on the water temperature criteria and objectives specified by the Trinity River ROD for anadromous salmonids in the Trinity River downstream of Lewiston Dam were evaluated by examining changes in DAT statistics at key temperature objective/compliance locations during July through December. Consideration of changes in water temperatures through the fall months after completion of the late-summer augmentation releases is important because of the potential latent effect that additional flow releases in August and September may have on reducing cold water storage in Trinity Lake and, therefore, on dam release and river temperatures in subsequent fall months (see Chapter 5, “Surface Water Quality”), and the ability of operations to achieve water temperature compliance objectives and temperature management criteria for spawning salmon. Differences in DAT of 1°F or less are considered to be similar given the typical accuracy and

[7] Chamberlain (2003) reported that stranding potential juvenile salmonids was less at pilot channel restoration sites than at sites with riparian encroachment berms.

precision of temperature measurement devices (± 0.5°F) and resolution of the CalSim II, HEC-5Q, and RBM10 models used for analysis (see Analytical Tools Appendix).

The mean and range of DATs during the July through September period at Douglas City are similar between Alternative 1 and the No Action Alternative, with a potential minor risk of exceeding optimal temperature thresholds by less than 1°F up to 3°F for up to four additional days in any one year for pre-spawning adult spring-run Chinook Salmon. During the latter half of September as spawning begins, some additional minor exceedances of optimal spawning temperatures of up to 2°F for one to nine days at Douglas City could occur primarily during extended drought periods and critically dry years, as occurred in the early 1990s (Table 7-4); although, in such instances, much of the river upstream of Douglas City would experience temperatures closer to the optimal spawning temperature threshold of ≤ 56°F. After October 1 through the end of December, when spring- and fall-run Chinook Salmon and Coho Salmon are spawning in the upper Trinity River, the mean and range of DATs down to the North Fork Trinity River confluence are similar between Alternative 1 and the No Action Alternative, with a minor increase in the number of days exceeding optimal spawning temperatures in dry and and critically dry years (Table 7-5); however, in such instances, much of the reach upstream of the North Fork Trinty River would likely experience cooler temperatures approaching and meeting the objective of ≤ 56°F.

Pacific Lamprey The temperature requirements and preferences of Pacific Lamprey and other lamprey species inhabiting the Klamath-Trinity River basin tributaries overlaps that of the sympatric anadromous salmonid species, but they are tolerant of somewhat warmer temperatures during the freshwater and reproductive lifestages (Moyle 2002). Given the relative similarity of the water temperatures, with minor differences in magnitude of the ranges in DATs, it is likely that the effects on Pacific Lampreys and other lamprey species would be similar between Alternative 1 and the No Action Alternative.

Table 7-4. Changes in Daily Average Water Temperatures Compared to NCRWQCB Temperature Objectives for Lewiston Dam to Douglas City Under the No Action Alternative and Alternative 1

Year	Water Year Type	7/1 to 9/14 ≤ 60°F (15.5°C) Average; (Range); [# days]		9/15 to 9/30 ≤ 56°F (13.3°C) Average; (Range); [# days]	
		No Action	**Alternative 1**	**No Action**	**Alternative 1**
1980	W	52 (49-55) [0]	52 (49-55) [0]	50 (49-51) [0]	50 (49-51) [0]
1981	**D**	**52 (51-55) [0]**	**52 (51-54) [0]**	**51 (51-53) [0]**	**52 (51-52) [0]**
1982	EW	52 (49-54) [0]	52 (49-54) [0]	50 (48-50) [0]	50 (48-50) [0]
1983	EW	53 (50-56) [0]	53 (50-56) [0]	52 (52-53) [0]	52 (52-53) [0]
1984	W	54 (52-56) [0]	54 (52-56) [0]	52 (51-54) [0]	52 (51-54) [0]
1985	**D**	**53 (52-54) [0]**	**53 (52-54) [0]**	**53 (52-53) [0]**	**53 (52-54) [0]**
1986	**W**	**51 (50-53) [0]**	**51 (50-53) [0]**	**50 (49-50) [0]**	**50 (49-50) [0]**
1987	**D**	**53 (51-55) [0]**	**53 (51-55) [0]**	**54 (54-55) [0]**	**55 (54-56) [0]**
1988	**D**	**54 (53-56) [0]**	**54 (52-55) [0]**	**53 (52-55) [0]**	**53 (53-55) [0]**
1989	**N**	**54 (51-56) [0]**	**54 (52-56) [0]**	**55 (54-56) [0]**	**55 (54-55) [0]**
1990	**D**	**56 (55-58) [0]**	**56 (55-58) [0]**	**56 (56-57) [7]**	**56 (55-56) [2]**
1991	**CD**	**59 (55-62) [33]**	**59 (56-63) [37]**	**59 (58-60) [15]**	**58 (56-60) [15]**
1992	**D**	**55 (53-57) [0]**	**55 (53-59) [0]**	**56 (55-56) [5]**	**57 (56-58) [14]**
1993	W	55 (51-61) [1]	56 (52-63) [2]	53 (53-55) [0]	55 (54-56) [0]
1994	**CD**	**55 (54-56) [0]**	**55 (53-56) [0]**	**55 (55-56) [0]**	**55 (54-56) [0]**
1995	**EW**	**56 (50-61) [6]**	**55 (50-60) [6]**	**50 (49-51) [0]**	**51 (50-52) [0]**
1996	**W**	**54 (51-57) [0]**	**54 (51-57) [0]**	**52 (52-53) [0]**	**52 (52-53) [0]**
1997	**W**	**53 (50-54) [0]**	**53 (50-54) [0]**	**52 (51-53) [0]**	**52 (51-53) [0]**
1998	EW	53 (50-56) [0]	53 (50-56) [0]	51 (50-52) [0]	51 (50-52) [0]
1999	W	54 (50-59) [0]	54 (50-60) [1]	52 (52-53) [0]	52 (52-53) [0]
2000	**W**	**53 (51-55) [0]**	**53 (51-55) [0]**	**53 (52-54) [0]**	**53 (52-54) [0]**
2001	**D**	**55 (54-56) [0]**	**54 (53-56) [0]**	**55 (54-55) [0]**	**55 (54-55) [0]**
2002	**N**	**53 (51-54) [0]**	**52 (50-54) [0]**	**52 (51-53) [0]**	**52 (51-52) [0]**
2003	**EW**	**53 (51-57) [0]**	**53 (50-57) [0]**	**51 (51-52) [0]**	**51 (51-52) [0]**
Summary of Differences		**Difference in DAT Mean (range)**	**Difference in Number of Exceedances**	**Difference in DAT Mean (range)**	**Difference in Number of Exceedances**
Flow Augmentation		-0.1°F (0.4 to -0.4°F)	+5	0°F (1.6 to -1.2°F)	+4
No Flow Augmentation		0.1°F (0.7 to 0°F)	+2	0.2°F (1.5 to 0°F)	0

Notes:

Averages are calculated for a 24-year period for the critical summer and fall reproductive periods for Trinity River spring- and fall-run Chinook Salmon and Coho Salmon

Water temperature management objectives for the Trinity River at Douglas City for protection of anadromous salmon freshwater life stages are shown for each period.

Years in bold font indicate representative years modeled with augmentation of late-summer flows for Alternative 1.

Key:
CD = critically dry
D = dry
DAT = daily average temperature
EW = extremely wet
N = normal
NCRWQCB = North Coast Regional Water Quality Control Board
W = wet

Table 7-5. Changes in Daily Average Water Temperatures Compared to NCRWQCB Temperature Objectives for Lewiston Dam to North Fork Trinity River Confluence Under the No Action Alternative and Alternative 1

Year	Water Year Type	10/1 to 12/31 ≤ 56°F (13.3°C) Average; (Range); [# days] No Action	10/1 to 12/31 ≤ 56°F (13.3°C) Average; (Range); [# days] Alternative 1
1980	W	49 (42-59) [10]	49 (42-59) [10]
1981	**D**	**49 (42-57) [1]**	**49 (42-57) [4]**
1982	EW	47 (41-56) [1]	47 (41-56) [1]
1983	EW	49 (42-56) [7]	49 (42-56) [7]
1984	W	46 (40-57) [1]	46 (40-57) [1]
1985	**D**	**49 (43-61) [9]**	**49 (43-61) [9]**
1986	**W**	**49 (44-56) [2]**	**49 (44-56) [2]**
1987	**D**	**50 (41-62) [23]**	**51 (41-62) [28]**
1988	**D**	**50 (40-60) [22]**	**50 (40-60) [24]**
1989	**N**	**51 (44-59) [20]**	**50 (44-59) [20]**
1990	**D**	**50 (42-62) [11]**	**50 (42-62) [11]**
1991	**CD**	**51 (44-65) [22]**	**50 (43-65) [22]**
1992	**D**	**51 (40-61) [26]**	**51 (40-62) [26]**
1993	W	49 (42-61) [10]	49 (42-61) [14]
1994	**CD**	**49 (41-61) [14]**	**49 (41-61) [18]**
1995	**EW**	**49 (41-55) [0]**	**49 (41-56) [0]**
1996	**W**	**49 (42-59) [11]**	**49 (42-59) [11]**
1997	**W**	**48 (41-57) [1]**	**48 (41-57) [1]**
1998	EW	47 (39-57) [1]	47 (39-57) [1]
1999	W	49 (43-57) [8]	49 (43-57) [8]
2000	**W**	**49 (44-58) [9]**	**49 (44-58) [9]**
2001	**D**	**50 (41-61) [19]**	**50 (41-63) [22]**
2002	**N**	**49 (41-58) [6]**	**50 (41-60) [15]**
2003	**EW**	**NA**	**NA**
Summary of Differences		**Difference in DAT Mean (range)**	**Difference in Number of Exceedances**
Flow Augmentation		0.1°F (0.6 to -0.4°F)	+26
No Flow Augmentation		0°F (0.1 to 0°F)	+4

Notes:
Averages are calculated for a 24-year period for the critical summer and fall reproductive periods for Trinity River spring- and fall-run Chinook Salmon and Coho Salmon
Water temperature management objective for the Trinity River at the North Fork Trinity River confluence for protection of anadromous salmon freshwater life stages is shown for each period.
Years in bold font indicate representative years modeled with augmentation of late-summer flows for Alternative 1.

Key:
CD = critically dry
D = dry
DAT = daily average temperature
EW = extremely wet
N = normal
NCRWQCB = North Coast Regional Water Quality Control Board
W = wet

Changes in Trinity River Spring Flow Release Patterns Under Alternative 1, Lewiston Dam would operate releases to conform to the Trinity River ROD flow management release schedules in all water year types; therefore, no change to the functional flow related fish habitat

management objectives for anadromous salmonids and other fish species in the Trinity River would occur compared to the No Action Alternative.

Changes in Trinity River Water Temperatures During Spring Flow Releases

Chinook Salmon, Coho Salmon, and Steelhead Consideration of changes in water temperatures through the spring and early summer months, following years when late-summer augmentation releases would occur, is important because of the potential latent effect that additional flow releases may have on reducing overall storage or cold water reserves in Trinity Lake and, therefore, on the ability of operations to achieve temperature management criteria for fish habitat throughout the following year (see Chapter 5, "Surface Water Quality"). Potential effects associated with changes in operation to provide additional late-summer flow releases from Lewiston Dam on the spring/early-summer water temperature management criteria were evaluated by examining changes in DAT statistics during mid-May to early-July. Differences in DAT of 1°F or less are considered to be similar given the typical accuracy and precision of temperature measurement devices (± 0.5°F) and resolution of the CalSim II, HEC-5Q, and RBM10 models used for analysis (see Analytical Tools Technical Appendix).

The mean and range of DATs during the spring/early-summer period at the North Fork Trinity River confluence (downstream to Weitchpec) are similar between Alternative 1 and the No Action Alternative (Tables 7-6 and 7-7), with a potential for only a minor increase of one or two days additional exceedances of temperature criteria in June and July, primarily during multiple consecutive dry water years. Given the similarity in spring/early-summer flows and water temperatures throughout the Trinity River between Alternative 1 and the No Action Alternative, habitat conditions for juvenile Chinook Salmon, Coho Salmon, and steelhead growth and outmigration survival would be expected to be similar.

Changes in Late Summer Flows in the Lower Klamath River Below the Trinity River Confluence

Chinook Salmon, Coho Salmon, and Steelhead The proposed action alternatives, including Alternative 1 compared to the No Action Alternative, would release additional flows from Lewiston Dam on the Trinity River to augment the late-summer baseflow in the lower Klamath River, below the Trinity River confluence, to a minimum of 2,800 cfs, in any year when flows may otherwise be less than this level. Furthermore, Alternative 1 would provide additional releases from Lewiston Dam for preventative and emergency pulse flows of 5,000 cfs in the lower Klamath River, for one and five days, respectively, as described in Chapter 2, "Description of Alternatives," to reduce the severity of Ich infections of adult salmon, when fish health monitoring detects infection levels that may merit additional flow to ameliorate conditions thought to contribute to virulence of the Ich parasite, which can cause an epizootic leading to fish die-offs.

As described under the impacts of the No Action Alternative, high densities of salmon in the lower Klamath River during the late-summer, resulting from any combination of high run-sizes, early shifts in run-timing of fall-run Chinook Salmon, thermal barriers to migration causing slowed migration, congregation, and extended residence time of adult salmon in restricted thermal refuges along the lower river; low seasonal flow levels (generally at or below the 90-percentile historic flow— see Figure 7-2); and warm water temperatures, can potentially trigger epizootic outbreaks of the fish diseases Ich and columnaris.

The potential effects of increases in the late-summer flows in lower Klamath River under Alternative 1 include an increase in average cross-sectional area of inundated river channel, increases in average water velocities in the channel, and changes in water temperature— all thought to be important in the disruption of infectivity and virulence of the Ich parasite. Increases in the baseflow would have varying effects on increasing habitat areas, dispersal opportunity, and migration cues for adult salmon to move upstream, depending on year and salmon abundance, which could reduce densities of fish in holding habitat.

Table 7-6. Change in Daily Average Water Temperatures Compared to Spring-Time Temperature Objectives Near the North Fork Trinity River Confluence Under the No Action Alternative and Alternative 1

Year	Water Year Type	4/15 to 5/22 ≤ 55.4° for N, W, & EW ≤ 59°F for D & CD WYs Average; (Range); [# days]		5/23 to 6/4 ≤ 59°F for N, W, & EW ≤ 62.6°F for D, CD Average; (Range); [# days]		6/5 to 7/9 ≤ 62.6°F for N, W, & EW Average; (Range); [# days]	6/5 to 6/15 ≤ 62.6°F for D, CD
		No Action	Alternative 1	No Action	Alternative 1	No Action	Alternative 1
1980	W	51 (47-56) [2]	51 (47-56) [2]	48 (46-51) [0]	48 (46-51) [0]	55 (49-57) [0]	55 (49-57) [0]
1981	**D**	**52 (49-57) [0]**	**52 (49-57) [0]**	**58 (54-60) [0]**	**58 (54-60) [0]**	**60 (57-62) [1]**	**60 (57-62) [1]**
1982	EW	51 (45-53) [0]	51 (45-53) [0]	47 (46-48) [0]	47 (46-48) [0]	52 (47-56) [0]	52 (47-56) [0]
1983	EW	49 (45-56) [1]	49 (45-56) [1]	53 (51-55) [0]	53 (51-54) [0]	55 (52-58) [0]	55 (52-58) [0]
1984	W	51 (47-54) [0]	51 (47-54) [0]	51 (49-53) [0]	51 (49-53) [0]	57 (51-60) [0]	57 (51-60) [0]
1985	**D**	**53 (50-57) [0]**	**53 (50-57) [0]**	**55 (52-57) [0]**	**55 (52-57) [0]**	**61 (56-65) [0]**	**61 (56-65) [0]**
1986	**W**	**50 (46-55) [0]**	**50 (46-55) [0]**	**51 (48-55) [0]**	**51 (48-55) [0]**	**56 (53-58) [0]**	**56 (53-58) [0]**
1987	**D**	**54 (49-60) [1]**	**54 (49-60) [1]**	**56 (53-59) [0]**	**56 (53-59) [0]**	**60 (58-62) [0]**	**60 (58-62) [0]**
1988	**D**	**52 (47-57) [0]**	**52 (47-57) [0]**	**56 (53-58) [0]**	**56 (53-58) [0]**	**55 (51-62) [2]**	**55 (51-62) [2]**
1989	**N**	**52 (49-59) [7]**	**52 (49-59) [7]**	**52 (48-56) [0]**	**52 (48-56) [0]**	**58 (53-59) [0]**	**58 (53-59) [0]**
1990	**D**	**53 (50-58) [0]**	**53 (50-58) [0]**	**52 (49-56) [0]**	**52 (49-56) [0]**	**60 (56-62) [0]**	**60 (56-62) [0]**
1991	**CD**	**54 (49-58) [0]**	**54 (49-58) [0]**	**58 (53-60) [0]**	**58 (53-61) [0]**	**63 (60-65) [0]**	**63 (60-65) [0]**
1992	**D**	**53 (50-58) [0]**	**53 (50-58) [0]**	**59 (55-63) [1]**	**59 (55-63) [1]**	**61 (55-63) [3]**	**61 (55-63) [3]**
1993	W	50 (47-53) [0]	50 (47-53) [0]	49 (48-50) [0]	49 (48-50) [0]	56 (49-59) [0]	56 (49-59) [0]
1994	**CD**	**56 (50-60) [7]**	**56 (50-60) [7]**	**59 (58-61) [0]**	**59 (58-61) [0]**	**60 (56-63) [0]**	**60 (55-63) [0]**
1995	**EW**	**49 (45-53) [0]**	**49 (45-53) [0]**	**48 (48-50) [0]**	**48 (47-49) [0]**	**53 (48-59) [0]**	**53 (48-59) [0]**
1996	**W**	**51 (47-55) [0]**	**51 (47-55) [0]**	**51 (47-54) [0]**	**51 (47-54) [0]**	**57 (53-60) [0]**	**57 (53-60) [0]**
1997	**W**	**52 (47-55) [0]**	**52 (47-55) [0]**	**50 (47-54) [0]**	**50 (47-53) [0]**	**56 (53-58) [0]**	**56 (53-58) [0]**
1998	EW	51 (46-55) [0]	51 (46-55) [0]	48 (45-53) [0]	48 (45-53) [0]	55 (52-57) [0]	55 (52-57) [0]
1999	W	51 (48-56) [3]	51 (48-56) [3]	52 (50-53) [0]	52 (50-53) [0]	56 (52-60) [0]	56 (52-60) [0]
2000	**W**	**51 (47-55) [0]**	**51 (47-55) [0]**	**52 (51-53) [0]**	**52 (51-53) [0]**	**57 (52-60) [0]**	**57 (52-60) [0]**
2001	**D**	**55 (49-60) [3]**	**55 (49-60) [3]**	**59 (57-63) [0]**	**59 (57-63) [0]**	**60 (58-62) [0]**	**60 (58-62) [0]**
2002	**N**	**51 (47-57) [3]**	**51 (47-57) [3]**	**53 (50-57) [0]**	**53 (50-57) [0]**	**57 (55-59) [0]**	**57 (55-59) [0]**
2003	**EW**	**50 (46-53) [0]**	**50 (46-53) [0]**	**49 (48-51) [0]**	**49 (48-51) [0]**	**54 (50-58) [0]**	**54 (50-58) [0]**

Table 7-6. Change in Daily Average Water Temperatures Compared to Spring-Time Temperature Objectives Near the North Fork Trinity River Confluence Under the No Action Alternative and Alternative 1 (contd.)

	4/15 to 5/22		**5/23 to 6/4**		**6/5 to 7/9**	
Summary of Differences	**Difference in DAT Mean (Range)**	**Difference in Number of Exceedances**	**Difference in DAT Mean (Range)**	**Difference in Number of Exceedances**	**Difference in DAT Mean (Range)**	**Difference in Number of Exceedances**
Flow Augmentation Years	0°F (0 to -0.1°F)	0	0°F (0 to -0.2°F)	0	0°F (0.1 to -0.1°F)	0
Non-Augmentation Years	0°F (0 to -0.1°F)	0	0°F (0 to -0.1°F)	0	0°F (0.1 to 0°F)	0

Notes:

Averages are calculated for a 24-year period for the critical spring and early summer rearing and outmigration periods for Trinity River anadromous salmonids

Water temperature management objectives for the Trinity River from Lewiston Dam to Weitchpec for protection of anadromous salmon freshwater life stages are shown for each period.

Years in bold font indicate representative years modeled with augmentation of late-summer flows for Alternative 1

Key:
CD = critically dry water year
D = dry water year
DAT = daily average temperature
EW = extremely wet water year
N = normal water year
W = wet

Table 7-7. Change in Daily Average Water Temperatures Compared to Spring-Time Temperature Objectives for Lewiston Dam to Weitchpec Under the No Action Alternative and Alternative 1

Year	Water Year Type	4/15 to 5/22 ≤ 55.4° for N, W, & EW ≤ 59°F for D & CD WYs Average; (Range); [# days]		5/23 to 6/4 ≤ 59°F for N, W, & EW ≤ 62.6°F for D, CD Average; (Range); [# days]		6/5 to 7/9 ≤ 62.6°F for N, W, & EW Average; (Range); [# days]	6/5 to 6/15 ≤ 62.6°F for D, CD
		No Action	Alternative 1	No Action	Alternative 1	No Action	Alternative 1
1980	W	55 (51-60) [24]	55 (51-60) [24]	52 (49-55) [0]	52 (49-55) [0]	61 (54-64) [10]	61 (54-64) [10]
1981	**D**	**56 (52-60) [4]**	**56 (52-60) [4]**	**63 (58-66) [8]**	**63 (58-66) [8]**	**65 (62-67) [0]**	**65 (62-67) [0]**
1982	EW	55 (47-58) [23]	55 (47-58) [23]	52 (50-54) [0]	52 (50-54) [0]	59 (51-63) [1]	59 (51-63) [1]
1983	EW	52 (47-61) [7]	52 (47-61) [7]	59 (57-61) [8]	59 (57-61) [7]	61 (58-64) [3]	61 (58-64) [3]
1984	W	53 (50-59) [4]	53 (50-59) [4]	56 (53-59) [0]	56 (53-59) [0]	63 (55-68) [24]	63 (55-68) [24]
1985	**D**	**56 (51-62) [4]**	**56 (51-62) [4]**	**60 (57-62) [0]**	**60 (57-62) [0]**	**67 (61-72) [5]**	**67 (61-72) [5]**
1986	**W**	**53 (50-58) [7]**	**53 (50-58) [7]**	**57 (51-61) [4]**	**57 (51-61) [4]**	**63 (60-65) [20]**	**63 (60-65) [20]**
1987	**D**	**59 (53-64) [18]**	**59 (53-64) [18]**	**61 (57-67) [3]**	**61 (57-67) [3]**	**68 (66-70) [4]**	**68 (66-70) [4]**
1988	**D**	**55 (49-62) [3]**	**55 (49-62) [3]**	**60 (57-64) [2]**	**60 (57-64) [2]**	**58 (55-66) [0]**	**58 (55-66) [0]**
1989	**N**	**57 (52-64) [19]**	**57 (52-64) [19]**	**57 (52-63) [3]**	**56 (52-63) [3]**	**64 (58-66) [30]**	**64 (58-66) [32]**
1990	**D**	**57 (53-62) [9]**	**57 (53-62) [9]**	**54 (53-58) [0]**	**54 (53-58) [0]**	**64 (58-65) [0]**	**64 (58-65) [0]**
1991	**CD**	**56 (52-60) [1]**	**56 (52-60) [1]**	**61 (58-63) [2]**	**61 (58-63) [2]**	**67 (63-69) [4]**	**67 (63-69) [5]**
1992	**D**	**58 (56-62) [10]**	**58 (56-62) [10]**	**65 (60-70) [12]**	**65 (60-70) [12]**	**67 (60-70) [7]**	**67 (60-70) [7]**
1993	W	54 (51-57) [10]	54 (51-57) [10]	55 (54-57) [0]	55 (54-57) [0]	63 (54-66) [23]	63 (54-67) [23]
1994	**CD**	**59 (53-65) [18]**	**59 (53-65) [18]**	**65 (61-66) [12]**	**65 (61-66) [12]**	**66 (62-70) [4]**	**66 (62-70) [4]**
1995	**EW**	**53 (47-58) [5]**	**53 (47-58) [5]**	**54 (53-55) [0]**	**54 (52-55) [0]**	**59 (53-67) [14]**	**59 (52-67) [14]**
1996	**W**	**54 (49-59) [14]**	**54 (49-59) [14]**	**55 (52-60) [1]**	**55 (52-60) [1]**	**63 (59-67) [20]**	**63 (59-67) [20]**
1997	**W**	**57 (52-62) [28]**	**57 (52-62) [29]**	**54 (51-59) [1]**	**54 (51-59) [0]**	**62 (57-65) [16]**	**62 (57-65) [16]**
1998	EW	55 (47-60) [18]	55 (47-60) [18]	51 (47-57) [0]	51 (47-57) [0]	61 (57-65) [5]	61 (57-65) [5]
1999	W	54 (49-60) [10]	54 (49-60) [10]	58 (55-59) [2]	58 (55-59) [2]	62 (55-66) [20]	62 (55-66) [20]
2000	**W**	**54 (50-57) [8]**	**54 (50-57) [8]**	**57 (55-58) [0]**	**57 (55-58) [0]**	**63 (58-67)[20]**	**63 (58-67) [20]**
2001	**D**	**58 (52-65) [13]**	**58 (52-65) [13]**	**65 (63-67) [13]**	**65 (63-67) [13]**	**65 (63-68) [0]**	**65 (63-68) [0]**
2002	**N**	**54 (51-60) [12]**	**54 (51-60) [12]**	**59 (54-62) [6]**	**59 (54-62) [6]**	**64 (61-66) [30]**	**64 (61-66) [30]**
2003	**EW**	**52 (48-55) [0]**	**52 (48-55) [0]**	**54 (52-56) [0]**	**54 (52-56) [0]**	**60 (55-65) [12]**	**60 (55-65) [12]**

Table 7-7. Change in Daily Average Water Temperatures Compared to Spring-Time Temperature Objectives for Lewiston Dam to Weitchpec Under the No Action Alternative and Alternative 1 (contd.)

	4/15 to 5/22		**5/23 to 6/4**		**6/5 to 7/9**	
Summary of Differences	**Difference in DAT Mean (Range)**	**Difference in Number of Exceedances**	**Difference in DAT Mean (Range)**	**Difference in Number of Exceedances**	**Difference in DAT Mean (Range)**	**Difference in Number of Exceedances**
Flow Augmentation Years	0°F (--)	+1	0°F (0 to -0.1°F)	0	0°F (0.1 to -0.1°F)	+3
Non-Augmentation Years	0°F (0 to -0.1°F)	0	0°F (--)	-1	0°F (0.1 to 0°F)	0

Notes:

Averages are calculated for a 24-year period for the critical spring and early summer rearing and outmigration periods for Trinity River anadromous salmonids

Water temperature management objectives for the Trinity River from Lewiston Dam to Weitchpec for protection of anadromous salmon freshwater life stages are shown for each period.

Years in bold font indicate representative years modeled with augmentation of late-summer flows for Alternative 1

Key:
CD = critically dry water year
D = dry water year
DAT = daily average temperature
EW = extremely wet water year
N = normal water year
W = wet

The effect of increased water velocities on disrupting and reducing the ability of the free-swimming infectious life-stage of the Ich parasite has been reported as being an important function of late-summer flow augmentation in the lower Klamath River (Strange 2015, USFWS 2015, USFWS and YTFP 2016). In-channel water velocities in the lower Klamath River, near Blue Creek, were modeled in a recent investigation and current speeds were reported to increase by an average of 0.21 feet per second faster when flows increased from 2,000 cfs to 2,800 cfs (USFWS and YTFP 2016). Additionally, USFWS and YTFP (2016) reported that modeled mean channel velocities also increased by 0.68 feet per second, with increasing discharge from 2,800 cfs to 5,000 cfs.

Current understanding of the mechanisms of the factors discussed above—that interact to result in Ich infection and epizootics that can lead to fish die-offs—is incomplete, and it is not possible to accurately quantify the reduced risk of disease that can be attributed to increased flows. However, given the potential of the proposed action's preventative base flow of 2,800 cfs, and the preventative and emergency pulse flows of 5,000 cfs, to affect increases in cross-sectional channel area to expand habitat space to some degree, increase water velocities that can reduce efficacy of Ich parasites from finding and attaching to adult salmon hosts, and potentially provide migration cues to further disperse adult salmon and reduce densities in the lower Klamath River, conditions under Alternative 1 would be expected to result in some level of reduced risk of Ich infection, epizootic outbreaks and consequent fish die-offs. In addition, reduction in the frequency of year-to-year parasite carryover effect may be reduced.

Pacific Lamprey Although, Pacific Lamprey may immigrate into the Klamath River from spring through summer, few are thought to reside in the lower Klamath River during the late-summer. No lamprey were reported among the fish that died in the 2002 mass fish mortality event (DFG 2004). The effects on lamprey of Alternative 1 compared to the No Action Alternative are thought to be similar as that for anadromous salmonids.

Green Sturgeon Green Sturgeon, including both northern DPS that spawn in the Klamath and Trinity Rivers, and southern DPS that may move into the Klamath River estuary to forage, may occur in the lower Klamath River during the late-summer. Some Green Sturgeon were reported among the fish that died in the 2002 mass fish mortality event (DFG 2004). The effects on Green Sturgeon of Alternative 1 compared to the No Action Alternative are thought to be of potentially similar benefit as for the anadromous salmonids.

Eulachon It is unclear whether this species has been extirpated from the Klamath River. However, Eulachon are reported to spawn in the lower Klamath River, up to 7 miles inland, during March through May, with the larvae washing out through the estuary to the ocean by June. Therefore, increased late-summer flows in the lower Klamath River would not affect Eulachon.

Changes in Late Summer Water Temperatures in the Lower Klamath River Below the Trinity River Confluence

<u>Chinook Salmon, Coho Salmon, and Steelhead</u> Reduction of water temperatures in the lower Klamath River is one of the intended benefits of the late-summer augmentation flow releases from Lewiston Dam. Effects on water temperatures in the lower Klamath River were evaluated by examining changes in DAT and 7DADM temperature statistics at RM 5.7, near the

head of the estuary, and at RM 16.5, near the Blue Creek confluence, during August 22 to September 22, when augmentation flows would occur. Differences in DAT and 7DADM of 1°F or less are considered to be similar given the typical accuracy and precision of temperature measurement devices (± 0.5°F) and resolution of the CalSim II, HEC-5Q, and RBM10 models used for analysis (see Analytical Tools Technical Appendix). Modeled temperature statistics were also compared for exceedances of 73.4°F, which is a temperature of particular importance because it is a thermal threshold known to inhibit migration of adult salmon (Strange 201b, 2012).

During late-summer flow augmentation operations, the DAT at the head of the estuary (RM 5.7) and near Blue Creek (RM 16.5) would be reduced by up to nearly 6°F in some years, averaging around 2°F, under Alternative 1 compared to the No Action Alternative (Tables 7-8 and 7-9), with a potential for a frequent reduction in the total number of days when DATs exceed the critical 73.4°F thermal migration barrier threshold. Similarly, the 7DADM at both locations would be reduced by up to nearly 5°F in some years, when flow augmentation occurs, averaging reductions of 1.3°F (RM 5.7) and 1.4°F (RM 16.5). The reduction in this metric under Alternative 1 also reflects that daily maximum temperatures would exhibt less frequent exccedance of the thermal migration barrier threshold.

Given the reduction in number of days when modeled DATs would exceed the thermal barrier threshold temperature, and the reduction in 7DADM, during late-summer flow augmentation in the lower Klamath River, thermal risk factors contributing to the potential for and severity of Ich infection would be reduced to some degree under Alternative 1 compared to the No Action Alternative.

Table 7-8. Changes in Maximum 7-Day Average of Daily Maximum Water Temperatures on the Lower Klamath River Near Klamath, California, Under the No Action Alternative and Alternative 1

Year	Water Year Type	No Action		Alternative 1	
		DAT Statistics Average; (Range); [# days]	**Maximum 7DADM (°F)**	**DAT Statistics Average; (Range); [# days]**	**Maximum 7DADM (°F)**
1980	W	68 (63-71) [0]	73	68 (63-71) [0]	73
1981	**D**	**70 (62-73) [0]**	**74**	**67 (62-71) [0]**	**73**
1982	EW	68 (62-74) [3]	75	68 (62-74) [3]	75
1983	EW	68 (64-70) [0]	74	68 (64-70) [0]	74
1984	W	69 (62-72) [0]	74	69 (62-72) [0]	74
1985	**D**	**66 (62-73) [0]**	**74**	**66 (62-73) [0]**	**74**
1986	**W**	**67 (58-74) [1]**	**75**	**67 (58-74) [1]**	**74**
1987	**D**	**68 (64-77) [5]**	**76**	**66 (62-71) [0]**	**72**
1988	**D**	**70 (62-75) [12]**	**76**	**66 (61-72) [0]**	**74**
1989	**N**	**68 (63-71) [0]**	**75**	**67 (63-69) [0]**	**74**
1990	**D**	**69 (66-71) [0]**	**73**	**68 (65-70) [0]**	**73**
1991	**CD**	**72 (68-76) [10]**	**76**	**68 (65-71) [0]**	**74**
1992	**D**	**70 (67-74) [1]**	**76**	**66 (62-69) [0]**	**74**
1993	W	69 (63-72) [0]	73	69 (63-72) [0]	73
1994	**CD**	**70 (66-74) [3]**	**76**	**64 (60-67) [0]**	**72**
1995	**EW**	**69 (67-71) [0]**	**73**	**69 (67-71) [0]**	**73**
1996	**W**	**68 (63-74) [1]**	**75**	**68 (63-74) [1]**	**75**
1997	**W**	**69 (64-72) [0]**	**74**	**69 (64-72) [0]**	**74**
1998	EW	70 (64-75) [4]	75	70 (64-75) [4]	75
1999	W	69 (66-74) [5]	75	69 (66-74) [5]	75
2000	**W**	**68 (64-73) [0]**	**74**	**68 (64-73) [0]**	**74**
2001	**D**	**70 (66-72) [0]**	**74**	**66 (63-69) [0]**	**73**
2002	**N**	**69 (65-74) [3]**	**75**	**64 (58-69) [0]**	**71**
2003	**EW**	**69 (63-73) [4]**	**76**	**67 (62-73) [1]**	**75**
Summary of Differences	**Difference in DAT Mean (Range)**		**Difference in 7DADM Mean (Range)**		**Difference in Number of Exceedances**
Flow Augmentation	-2.1°F (0 to -5.8°F)		-1.3°F (0 to -4.5°F)		-37
Non-Augmentation	0°F (0.1 to 0°F)		0°F (0.1 to 0°F)		0

Notes:
Averages are calculated for a 24-year period during the flow augmentation period, August 22 to September 22
Daily average water temperatures ≥ 73.4°F have been reported to inhibit migratory behavior of adult salmon.
Years in bold font indicate representative years modeled with augmentation of late-summer flows for Alternative 1.
Key:
7DADM = 7-day average daily maximum
CD = critically dry
D = dry
DAT = daily average temperature
EW = extremely wet
N = normal
W = wet

Table 7-9. Changes in Maximum 7-Day Average of Daily Maximum Water Temperatures on the Lower Klamath River Near Blue Creek Under the No Action Alternative and Alternative 1

Year	Water Year Type	No Action		Alternative 1	
		DAT Statistics Average; (Range); [# days]	Maximum 7DADM (°F)	DAT Statistics Average; (Range); [# days]	Maximum 7DADM (°F)
1980	W	67 (62-70) [0]	72	67 (62-70) [0]	72
1981	**D**	**69 (62-72) [0]**	**74**	**66 (62-70) [0]**	**73**
1982	EW	68 (62-74) [4]	75	68 (62-74) [4]	75
1983	EW	67 (64-70) [0]	74	67 (64-70) [0]	74
1984	W	69 (61-72) [0]	74	69 (61-72) [0]	74
1985	**D**	**66 (61-73) [1]**	**74**	**66 (61-73) [0]**	**74**
1986	**W**	**67 (58-73) [0]**	**74**	**66 (58-73) [0]**	**73**
1987	**D**	**68 (64-77) [5]**	**76**	**66 (61-72) [0]**	**71**
1988	**D**	**69 (61-74) [3]**	**75**	**66 (60-71) [0]**	**73**
1989	**N**	**68 (62-71) [0]**	**74**	**66 (62-69) [0]**	**73**
1990	**D**	**68 (66-71) [0]**	**73**	**67 (65-70) [0]**	**73**
1991	**CD**	**71 (68-75) [9]**	**76**	**67 (65-70) [0]**	**73**
1992	**D**	**69 (66-74) [3]**	**76**	**66 (62-69) [0]**	**73**
1993	W	68 (62-73) [0]	73	69 (62-73) [0]	73
1994	**CD**	**70 (65-73) [1]**	**75**	**64 (60-67) [0]**	**72**
1995	**EW**	**69 (67-71) [0]**	**73**	**69 (67-71) [0]**	**73**
1996	**W**	**68 (62-74) [1]**	**74**	**68 (62-74) [1]**	**74**
1997	**W**	**68 (63-71) [0]**	**74**	**68 (63-71) [0]**	**74**
1998	EW	70 (64-75) [4]	75	70 (64-75) [4]	75
1999	W	69 (66-74) [3]	75	69 (66-74) [3]	75
2000	**W**	**68 (64-72) [0]**	**73**	**68 (64-72) [0]**	**73**
2001	**D**	**69 (66-72) [0]**	**73**	**66 (62-68) [0]**	**72**
2002	**N**	**69 (65-73) [0]**	**74**	**63 (58-67) [0]**	**71**
2003	**EW**	**69 (63-74) [4]**	**76**	**67 (62-72) [1]**	**75**
Summary of Differences	**Difference in DAT Mean (Range)**		**Difference in 7DADM Mean (Range)**		**Difference in Number of Exceedances**
Flow Augmentation Years	-2.2°F (0 to -6.2°F)		-1.4°F (0 to -4.8°F)		-25
Non-Augmentation Years	0°F (0.1 to 0°F)		0°F (--)		0

Notes:
Averages are calculated for a 24-year period during the flow augmentation period, August 22 to September 22
Daily average water temperatures ≥ 73.4°F have been reported to inhibit migratory behavior of adult salmon.
Years in bold font indicate representative years modeled with augmentation of late-summer flows for Alternative 1.
Key:
7DADM = 7-day average daily maximum
CD = critically dry
D = dry
DAT = daily average temperature
EW = extremely wet
N = normal
W = wet

Pacific Lamprey Similar to the previous discussion of effects of late-summer augmentation flows, the effects of water temperatures associated with late-summer augmentation flows in the lower Klamath River under Alternative 1, compared to the No Action Alternative, are thought to be negligible for Pacific Lamprey.

Green Sturgeon Similar to the previous discussion of effects of late-summer augmentation flows, water temperatures associated with late-summer augmentation flows in the lower Klamath River under Alternative 1, compared to the No Action Alternative, are thought to be of potentially similar benefit to Green Sturgeon as for the anadromous salmonids.

Eulachon Similar to the previous discussion of effects of late-summer augmentation flows, water temperatures associated with late-summer augmentation flows in the lower Klamath River under Alternative 1, compared to the No Action Alternative, would not affect Eulachon.

Central Valley and Bay-Delta Region

Fish Habitat Conditions in the CVP and SWP Reservoirs

Changes in Black Bass Nesting Success The analysis of effects associated with changes in operation on reservoir fishes relied on evaluation of changes in available habitat (reservoir elevations) and anticipated changes in black bass nesting success.

Under Alternative 1, reservoir elevations would be similar (less than 1 percent difference) compared to the No Action Alternative. Therefore, there would be minimal changes in nesting success for Largemouth Bass, Smallmouth Bass, and Spotted Bass in Shasta Lake, Oroville Lake, and Folsom Lake (Tables 7-10 through 7-12). Whiskeytown Reservoir has 100 percent nesting success under all alternatives in all months for all species for both the No Action Alternative and Alternative 1.

Table 7-10. Black Bass Nesting Success in Percent Survival in Shasta Reservoir for the No Action Alternative and Alternative 1

	March		April		May		June	
Water Year Type	**No Action**	**Alt 1 (Difference from No Action)**	**No Action**	**Alt 1 (Difference from No Action)**	**No Action**	**Alt 1 (Difference from No Action)**	**No Action**	**Alt 1 (Difference from No Action)**
Largemouth Bass								
Wet	100	0	100	0	100	0	41	0
AN	100	0	100	0	100	0	8	0
BN	100	0	100	0	100	0	7	0
Dry	100	0	100	0	100	0	1	0
Critical	100	0	85	2	50	1	0	0
All Years	100	0	100	0	100	0	8	0
Smallmouth Bass								
Wet	100	0	100	0	100	0	36	1
AN	100	0	100	0	100	0	10	0
BN	100	0	100	0	86	0	8	0
Dry	100	0	100	0	85	0	3	0
Critical	100	0	73	1	43	0	0	0
All Years	100	0	100	0	100	0	9	0
Spotted Bass								
Wet	100	0	100	0	100	0	100	0
AN	100	0	100	0	100	0	61	0
BN	100	0	100	0	100	0	59	3
Dry	100	0	100	0	100	0	51	-5
Critical	100	0	100	0	100	0	18	2
All Years	100	0	100	0	100	0	61	0

Key:
Alt = Alternative
AN = Above Normal
BN = Below Normal

Table 7-11. Black Bass Nesting Success in Percent Survival in Oroville Reservoir for the No Action Alternative and Alternative 1

Water Year Type	March		April		May		June	
	No Action	**Alt 1 (Difference from No Action)**	**No Action**	**Alt 1 (Difference from No Action)**	**No Action**	**Alt 1 (Difference from No Action)**	**No Action**	**Alt 1 (Difference from No Action)**
Largemouth Bass								
Wet	100	0	100	0	100	0	100	0
AN	100	0	100	0	100	0	27	0
BN	100	0	100	0	100	0	0	0
Dry	100	0	100	0	100	0	0	0
Critical	100	0	100	0	100	0	0	0
All Years	100	0	100	0	100	0	9	0
Smallmouth Bass								
Wet	100	0	100	0	100	0	85	0
AN	100	0	100	0	100	0	25	0
BN	100	0	100	0	100	0	3	0
Dry	100	0	100	0	100	0	0	0
Critical	100	0	100	0	92	1	0	0
All Years	100	0	100	0	100	0	10	0
Spotted Bass								
Wet	100	0	100	0	100	0	100	0
AN	100	0	100	0	100	0	87	0
BN	100	0	100	0	100	0	50	0
Dry	100	0	100	0	100	0	13	0
Critical	100	0	100	0	100	0	34	-4
All Years	100	0	100	0	100	0	62	0

Key:
Alt = Alternative
AN = Above Normal
BN = Below Normal

Table 7-12. Black Bass Nesting Success in Percent Survival in Folsom Reservoir for the No Action Alternative and Alternative 1

	March		April		May		June	
Water Year Type	**No Action**	**Alt 1 (Difference from No Action)**	**No Action**	**Alt 1 (Difference from No Action)**	**No Action**	**Alt 1 (Difference from No Action)**	**No Action**	**Alt 1 (Difference from No Action)**
Largemouth Bass								
Wet	100	0	100	0	100	0	100	0
AN	100	0	100	0	100	0	61	0
BN	100	0	100	0	100	0	50	0
Dry	100	0	100	0	100	0	20	0
Critical	100	0	100	0	100	0	22	-1
All Years	100	0	100	0	100	0	52	-1
Smallmouth Bass								
Wet	100	0	100	0	100	0	100	0
AN	100	0	100	0	100	0	53	0
BN	100	0	100	0	100	0	44	0
Dry	100	0	100	0	100	0	19	0
Critical	100	0	100	0	100	0	21	-1
All Years	100	0	100	0	100	0	45	0
Spotted Bass								
Wet	100	0	100	0	100	0	100	0
AN	100	0	100	0	100	0	100	0
BN	100	0	100	0	100	0	100	0
Dry	100	0	100	0	100	0	78	0
Critical	100	0	100	0	100	0	81	-1
All Years	100	0	100	0	100	0	100	0

Key:
Alt = Alternative
AN = Above Normal
BN = Below Normal

Changes in Cold Water Fish Habitat Changes in CVP and SWP water supplies and operations under Alternative 1, as compared to the No Action Alternative, generally would result in similar reservoir storage in CVP and SWP reservoirs in the Central Valley Region. Changes in storage levels in Shasta Lake, Lake Oroville, and Folsom Lake would be less than 2 percent under Alternative 1 compared to the No Action Alternative, as summarized in Chapter 4, "Surface Water Supply and Management." These minimal differences in reservoir storage in all water year types would result in minor, if any, changes to cold water fish habitat under Alternative 1 compared to the No Action Alternative.

Aquatic Habitat Conditions in Rivers Downstream from the CVP and SWP Reservoirs

Changes in Juvenile Chinook Salmon Production - SALMOD Output SALMOD results indicate that potential juvenile production under Alternative 1 would be the similar (less than 3 percent difference) to the No Action Alternative in all water year types for all runs of Chinook Salmon except for fall-run Chinook Salmon (Table 7-13).

There are 4 out of 12 critical water years in which production is decreased by more than 16 percent for fall-run Chinook Salmon. The overall average change in critical water years are over

5 percent, however the overall production in all water years decreased by less than 1 percent compared with the No Action Alternative.

Late fall-run Chinook Salmon, and steelhead through their similarity, experience production decreases by more than 10 percent in 2 out of 12 critical years and 2 out of 18 dry years. The overall average for critical and dry water years is less than 3 percent and 1 percent, respectively, and the overall change in production for all water year types is less than 1 percent compared to the No Action Alternative.

Winter-run Chinook Salmon experience a decrease in production by more than 7 percent in 3 of 12 critical water years, but experience a greater than 7 percent increase in production in 1 critical water year. The overall average decrease in critical water years is less than 2 percent, and the overall change in production for all water year types is less than 1 percent compared to the No Action Alternative.

Spring-run Chinook Salmon, which have a very low spawning population in the Sacramento River, could experience 100 percent mortality in 2 critical water years, however, that is compared with No Action Alternative productions of 10 and 32 juveniles. In 4 other critical water years, they could experience a decrease in production ranging from 7 to 64 percent relative to the No Action Alternative. In one critical year, they could experience an increase in production of nearly 24 percent compared to the No Action Alternative. Populations of 500 or more spawning Chinook Salmon are considered necessary for accurate results using SALMOD because it is a deterministic model that relies on the “law of large numbers.” When populations are *low* (an arbitrary term), mean responses are quickly affected by environmental stochasticity and individual variability.

Table 7-13. Juvenile Chinook Salmon Production Based on SALMOD Results for Alternative 1

Water Year Type	No Action Alternative (Average Production)	Alternative 1 (Difference from No Action)	Alternative 1 (Percent Change)
Fall-Run Chinook Salmon			
Critical	13,058,552	-745,197	-5.7
Dry	29,967,217	36,551	0.1
Below Normal	30,112,903	-194,033	-0.6
Above Normal	30,324,698	45,599	0.2
Wet	29,159,993	66,118	0.2
All Water Years	27,275,865	-99,746	-0.4
Late Fall-Run Chinook Salmon			
Critical	5,245,425	-114,999	-2.2
Dry	5,648,977	-42,391	-0.8
Below Normal	5,787,938	-5,749	-0.1
Above Normal	5,929,655	-22,349	-0.4
Wet	5,868,372	-11,305	0.0
All Water Years	5,720,957	-35,135	-0.2
Winter-Run Chinook Salmon			
Critical	2,382,579	-44,027	-1.8
Dry	3,327,324	-522	0.0
Below Normal	3,250,781	2,641	0.1
Above Normal	3,149,290	11,693	0.4
Wet	3,139,415	371	0.0
All Water Years	3,090,275	-4,441	-0.1
Spring-Run Chinook Salmon			
Critical	68,168	3,499	5.1
Dry	416,959	1,725	0.4
Below Normal	447,950	-1,628	-0.4
Above Normal	465,691	-574	-0.1
Wet	467,027	-739	-0.2
All Water Years	392,786	401	0.1

Changes in Winter-Run Chinook Salmon Production - Interactive Object-Oriented Simulation Output The IOS model predicted adult escapement trajectories for winter-run Chinook Salmon across the simulated water years. Under Alternative 1, average adult escapement was 6,513, and under the No Action Alternative, average escapement was 6,610. Adult escapement estimates were based on the water year type in the third year previous to the adult return, the assumed time for spawning, rearing and outmigration. Three of 11 critical, 2 of 19 dry, 1 out of 10 below normal, 2 out of 11 above normal, and 3 out of 25 wet water years would experience decreases greater than 6 percent under Alternative 1 relative to the No Action Alternative.

Similar to adult escapement, the IOS model predicted similar (less than 2 percent difference) egg survival, smolt production, and survival downstream from RBPP and in the Delta for winter-run Chinook Salmon between Alternative 1 and the No Action Alternative across the 81 water years (Table 7-14). However, Under Alternative 1, during critical years, fry-to-smolt survival would be affected, showing an average of 9 percent decrease in survival relative to the No Action Alternative, caused by 5 of the 12 years with significantly decreased survival.

Smolt production would be decreased by over 5 percent in critical years, but the overall smolt production for all simulated years would be less than 2 percent, less than production under the No Action Alternative. Most years in which the decreased survival occurred were years in which overall production was low (typically less than 1 million smolts).

Table 7-14. IOS Model Results for Winter-Run Chinook Salmon for Alternative 1

Water Year Type	No Action	Alternative 1	Alternative 1 (Percent Change)
Adult Escapement			
Critical	4,806	4,741	-1
Dry	6,772	6,697	-1
Below Normal	5,249	5,229	0
Above Normal	5,426	5,304	-2
Wet	8,887	8,728	-2
All Water Years	6,793	6,691	-1
Egg Survival			
Critical	0.55	0.54	-1.8
Dry	0.99	0.99	0
Below Normal	0.98	0.98	0
Above Normal	0.99	0.99	0
Wet	0.99	0.99	-0.1
All Water Years	0.92	0.92	0
Fry-to-Smolt Survival			
Critical	0.48	0.44	-8.6
Dry	0.93	0.93	0.1
Below Normal	0.93	0.93	0
Above Normal	0.94	0.94	0
Wet	0.93	0.93	0
All Water Years	0.87	0.86	-0.7
Smolt Production			
Critical	3,568,552	3,384,779	-5.1
Dry	6,143,220	6,103,382	-0.6
Below Normal	5,329,551	5,326,125	-0.1
Above Normal	4,466,911	4,339,296	-2.9
Wet	6,916,239	6,789,627	-1.8
All Water Years	5,600,444	5,504,896	-1.7
Red Bluff Pumping Plant to Delta Survival			
Critical	0.24	0.24	0.1
Dry	0.24	0.24	0.0
Below Normal	0.23	0.23	0.0
Above Normal	0.24	0.24	0.0
Wet	0.23	0.23	0.0
All Water Years	0.23	0.23	0.0
Delta Survival			
Critical	0.32	0.32	0.1
Dry	0.40	0.40	0.0
Below Normal	0.41	0.41	0.0
Above Normal	0.38	0.38	0.0
Wet	0.40	0.40	0.0
All Water Years	0.39	0.39	0.0

Changes in Water Temperature Long-term daily average monthly water temperature in Clear Creek at Igo and in the Sacramento River downstream from Clear Creek, at Balls Ferry, Jellys Ferry, and Bend Bridge under Alternative 1 would generally be similar to (less than 0.5°F difference) to water temperatures under the No Action Alternative (See Chapter 5, "Surface Water Quality"). The exception to this would occur in September of critical water years on the Sacramento River downstream from Clear Creek, Balls Ferry, and Jellys Ferry, where average water temperatures could increase by 0.5 ºF to 0.6ºF.

Changes in Exceedances of Water Temperature Thresholds Average monthly water temperatures from May through October under both the No Action Alternative and Alternative 1 exceed the water temperature threshold of 56°F in the Sacramento River below Clear Creek less than 14 percent of the time. In the Sacramento River at Balls Ferry for winter-run and spring-run Chinook Salmon spawning and egg incubation, the water temperature threshold would be exceeded by 22 percent of the time under both the No Action Alternative and Alternative 1. Water temperature thresholds would be exceeded nearly 40 percent of the months with designated thresholds under the No Action Alternative and Alternative 1 at Jellys Ferry. At Bend Bridge, the frequency of exceedances would be similar under Alternative 1 (62 percent) to the No Action Alternative (61 percent). The difference between the No Action Alternative and Alternative 1 is less than 1 percent. While there are minimal differences in meeting the water temperature thresholds, the slight increase in water tempareture exceedence is sufficient to result in the differences shown for the modeling results in SALMOD and IOS.

Average monthly water temperatures in Clear Creek at Igo between June and September exceed the 60°F threshold under both the No Action Alternative and Alternative 1, less than 1 percent of the time. The September to October threshold of 56°F would be exceeded by 12 percent under the No Action Alternative, and less than 10 percent under Alternative 1.

Changes in Weighted Usable Area As described above for the assessment methodology, 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 habitat for winter-run Chinook Salmon, fall-run Chinook Salmon, late fall-run Chinook Salmon, and steelhead between Keswick Dam and Battle Creek, flows in the Sacramento River below Keswick Dam indicate that, in general, there would be similar amounts of spawning habitat, suitable fry rearing habitat, and suitable juvenile rearing habitat under Alternative 1 and the No Action Alternative (less than 1 percent difference).

Based on the simulated flows, WUA values for spring-run Chinook Salmon, fall-run Chinook Salmon, and steelhead in Clear Creek are similar, with a less than 1 percent difference in WUA between Alternative 1 and the No Action Alternative, for spawning, fry rearing, and juvenile rearing habitat.

The amount of suitable spawning habitat, fry rearing habitat, and juvenile rearing habitat would be similar, less than 1 percent difference, between Alternative 1 and the No Action Alternative

for fall-run Chinook Salmon and steelhead in the lower Feather River and the lower American River.

Fish Habitat Conditions in Bay-Delta

Changes in Delta Hydrodynamics Under Alternative 1, Delta outflow would be similar (less than 1 percent difference) to the No Action Alternative (See Chapter 4, "Surface Water Supply and Management").

The OMR flows would be similar in almost all months between Alternative 1 and the No Action Alternative, with the long-term average ranging from -6,219 to 914 cfs (compared with -6,217 to 914 cfs under the No Action Alternative) from December through June under Alternative 1 (See Chapter 4, "Surface Water Supply and Management"). In June of critical water years, there was a 7 percent increase in negative flows (a change from -1,414 cfs under No Action Alternative to -1,512 cfs under Alternative 1). This change, however, is substantially below the -5,000 cfs criteria, and therefore, does not result in an adverse effect to Delta fishes.

As a result, Delta fishes, including Delta Smelt, Longfin Smelt, all runs of Chinook Salmon, steelhead, and Green Sturgeon would not be affected by the implementation of the action resulting from a change in Delta hydrodynamics.

Changes in X2 Location Overall, the quantitative results from the numerical models suggest that operation under the Alternative 1 would result in a less than 1 percent change in the X2 location, relative to the No Action Alternative in all months and all water year types. Implementing Alternative 1 would not affect fish habitat resulting from the placement of X2.

Trinity River Record of Decision Flow Rescheduling Alternative (Alternative 2)

As described in Chapter 3, "Considerations for Describing Affected Environment and Enviromental Consequences," Alternative 2 is compared to the No Action Alternative.

Lower Klamath and Trinity River Region

Changes in CVP Reservoir Storage and Surface Elevations Alternative 2 would reschedule a portion of the spring/early-summer component of the Trinity River ROD flows for release in the late-summer, as compared to the No Action Alternative. This would result in some lower end-of-year reservoir storage in Trinity Lake, (see Chapter 4, "Surface Water Supply"). However, end-of-year storage in Trinity Lake would decrease by no more than 2 percent in any water year type compared to the No Action Alternative. Monthly storage in Trinity Lake would increase during the spring and early summer months from May to July by up to 1 to 4 percent, except in extremely wet years when it could be 1 to 2 percent less than the No Action Alternative. Additional information related to the CalSim II and DSM2 modeling used to generate monthly reservoir elevations is provided in the Analytical Tools Technical Appendix.

Using Trinity Lake storage as an indicator of habitat available to fish species inhabiting the reservoir, the amount of habitat for reservoir fishes would generally be similar in most months, except for increases in May through July of normal and drier water years, decreases of up to 2 percent in September of dry water years, and decreases of up to 2 percent in most months of extremely wet water years, under Alternative 2 as compared to the No Action Alternative.

As shown in Figures 7-3 through 7-5, nest survival for all the three black bass species in Trinity Lake would be somewhat greater under Alternative 2 as compared to the No Action or Alternative 1. The likelihood of nest survival of 40 percent or greater for Largemouth Bass and Smallmouth Bass could increase by up to 2 percent. Spotted Bass nesting success would be 40 percent or greater nearly 100 percent of the time under all alternatives.

Overall, the comparison of storage and the analysis of nesting suggest that effects of Alternative 2 on reservoir fishes in Trinity Lake would be largely similar to those under the No Action Alternative, with a potential for modestly higher springtime nesting success rates for Largemouth and Smallmouth Bass.

Aquatic Habitat Conditions in the Lower Klamath and Trinity Rivers

Changes in Trinity River Flows During the Late Summer

Chinook Salmon, Coho Salmon, and Steelhead The Lewiston Dam late-summer augmentation flow releases under Alternative 2 are the same as described for Alternative 1. Accordingly, similar changes compared to the No Action Alternative, would be expected under Alternative 2 in terms of (1) the extent of the river downstream of Lewiston Dam providing suitable habitat and water temperatures for rearing juvenile salmonids, (2) the potential risks of overtopping riverside riparian berms and subsequent stranding of juvenile salmonids during downramping after the augmentation flow period, and (3) the potential for interrupting spawning and dewatering redds of spring-run Chinook Salmon.

Pacific Lamprey Adult Pacific Lamprey migrate into the Klamath-Trinity River basin tributaries from spring through summer before spawning the following winter and spring. Juvenile lamprey larvae (ammocoetes) rear year-round in the mainstem Trinity River and its tributaries in low-velocity pools and channel margins with a dominant substrate of fine silt, sand, or small gravels (USFWS 2010). Increased late-summer augmentation flows may cause increased water velocities and disturbance of fine sediments along the summer baseflow channel where lamprey ammocoetes are living. Because the range of augmentation flows under Alternative 2 would be within the typical range of annual fluctuations in the upper Trinity River, which lampreys experience over their freshwater juvenile life stage, it is expected that juvenile lampreys will redistribute to other areas of suitable habitat over the course of the augmentation flow cycle, if disturbed by higher water velocities.

Changes in Trinity River Water Temperatures in Late Summer through Fall

Chinook Salmon, Coho Salmon, and Steelhead The potential changes to water temperatures during the late-summer and fall in the upper Trinity River under Alternative 2 compared to the No Action Alternative would be different from that of Alternative 1 because Alternative 2 would reschedule the spring/early summer component of the Trinity River ROD flow release schedule to provide additional late-summer flow releases from Lewiston Dam.

The mean and range of DATs during the July through September period at Douglas City would be generally similar, with a reduction in potential number of days exceeding optimal temperature thresholds in any one year for pre-spawning adult spring-run Chinook Salmon under Alternative 2. During the latter half of September as spawning begins, DATs would be similar between Alternative 2 and the No Action Alternative, with potentially fewer exceedances under Alternative 2 in dry and critically dry years (Table 7-15). After October 1 through the end of

December, when spring- and fall-run Chinook Salmon and Coho Salmon are spawning in the upper Trinity River, the mean and range of DATs down to the North Fork Trinity River confluence are similar between Alternative 2 and the No Action Alternative, with a minor increase in the number of days exceeding optimal spawning temperatures in dry and and critically dry years (Table 7-16); however, in such instances, much of the reach upstream of the North Fork Trinty River would likely experience cooler temperatures approaching and meeting the objective of ≤ 56°F.

Table 7-15. Changes in Daily Average Water Temperatures Compared to NCRWQCB Temperature Objectives for Lewiston Dam to Douglas City Under the No Action Alternative and Alternative 2

Year	Water Year Type	7/1 to 9/14 ≤ 60°F Average; (Range); [# days]		9/15 to 9/30 ≤ 56°F Average; (Range); [# days]	
		No Action	**Alternative 2**	**No Action**	**Alternative 2**
1980	W	52 (49-55) [0]	52 (49-55) [0]	50 (49-51) [0]	50 (49-51) [0]
1981	**D**	**52 (51-55) [0]**	**52 (51-54) [0]**	**51 (51-53) [0]**	**52 (51-52) [0]**
1982	EW	52 (49-54) [0]	52 (49-54) [0]	50 (48-50) [0]	50 (48-50) [0]
1983	EW	53 (50-56) [0]	53 (50-56) [0]	52 (52-53) [0]	52 (52-53) [0]
1984	W	54 (52-56) [0]	54 (52-56) [0]	52 (51-54) [0]	52 (51-54) [0]
1985	**D**	**53 (52-54) [0]**	**53 (52-54) [0]**	**53 (52-53) [0]**	**53 (52-53) [0]**
1986	**W**	**51 (50-53) [0]**	**51 (50-53) [0]**	**50 (49-50) [0]**	**50 (49-50) [0]**
1987	**D**	**53 (51-55) [0]**	**53 (51-54) [0]**	**54 (54-55) [0]**	**54 (53-55) [0]**
1988	**D**	**54 (53-56) [0]**	**54 (52-55) [0]**	**53 (52-55) [0]**	**53 (52-54) [0]**
1989	**N**	**54 (51-56) [0]**	**54 (52-56) [0]**	**55 (54-56) [0]**	**54 (54-55) [0]**
1990	**D**	**56 (55-58) [0]**	**56 (55-58) [0]**	**56 (56-57) [7]**	**56 (55-57) [6]**
1991	**CD**	**59 (55-62) [33]**	**58 (55-61) [12]**	**59 (58-60) [15]**	**58 (56-59) [15]**
1992	**D**	**55 (53-57) [0]**	**55 (53-57) [0]**	**56 (55-56) [5]**	**55 (55-56) [1]**
1993	W	55 (51-61) [1]	55 (51-61) [2]	53 (53-55) [0]	54 (53-55) [0]
1994	**CD**	**55 (54-56) [0]**	**54 (53-56) [0]**	**55 (55-56) [0]**	**55 (54-56) [0]**
1995	**EW**	**56 (50-61) [6]**	**55 (50-60) [6]**	**50 (49-51) [0]**	**51 (50-52) [0]**
1996	**W**	**54 (51-57) [0]**	**54 (51-56) [0]**	**52 (52-53) [0]**	**52 (52-53) [0]**
1997	**W**	**53 (50-54) [0]**	**53 (50-54) [0]**	**52 (51-53) [0]**	**52 (51-53) [0]**
1998	EW	53 (50-56) [0]	53 (50-56) [0]	51 (50-52) [0]	51 (50-52) [0]
1999	W	54 (50-59) [0]	53 (51-55) [0]	52 (52-53) [0]	52 (52-53) [0]
2000	**W**	**53 (51-55) [0]**	**53 (51-55) [0]**	**53 (52-54) [0]**	**53 (52-54) [0]**
2001	**D**	**55 (54-56) [0]**	**54 (53-56) [0]**	**55 (54-55) [0]**	**55 (54-56) [0]**
2002	**N**	**53 (51-54) [0]**	**52 (50-54) [0]**	**52 (51-53) [0]**	**52 (51-52) [0]**
2003	**EW**	**53 (51-57) [0]**	**53 (50-57) [0]**	**51 (51-52) [0]**	**51 (51-52) [0]**
Summary of Differences		**Difference in DAT Mean (range)**	**Difference in Number of Exceedances**	**Difference in DAT Mean (range)**	**Difference in Number of Exceedances**
Flow Augmentation		-0.3°F (0 to -1.4°F)	-21	-0.2°F (0.5 to -1.3°F)	-5
No Flow Augmentation		0°F (0.1 to 0°F)	+1	0°F (0.2 to 0°F)	0

Notes:

Averages are calculated for a 24-year period for the critical summer and fall reproductive periods for Trinity River spring- and fall-run Chinook Salmon and Coho Salmon

Water temperature management objectives for the Trinity River at Douglas City for protection of anadromous salmon freshwater life stages are shown for each period.

Years in bold font indicate representative years modeled with augmentation of late-summer flows for Alternative 2.

Key:
CD = critically dry
D = dry
DAT = daily average temperature
EW = extremely wet
N = normal
NCRWQCB = North Coast Regional Water Quality Control Board
W = wet

Table 7-16. Changes in Daily Average Water Temperatures Compared to NCRWQCB Temperature Objectives for Lewiston Dam to North Fork Trinity River Confluence Under the No Action Alternative and Alternative 2

Year	Water Year Type	10/1 to 12/31 ≤ 56°F Average; (Range); [# days]	10/1 to 12/31 ≤ 56°F Average; (Range); [# days]
		No Action	**Alternative 2**
1980	W	49 (42-59) [10]	49 (42-59) [10]
1981	**D**	**49 (42-57) [1]**	**49 (42-57) [3]**
1982	EW	47 (41-56) [1]	47 (41-56) [1]
1983	EW	49 (42-56) [7]	49 (42-56) [7]
1984	W	46 (40-57) [1]	46 (40-57) [1]
1985	**D**	**49 (43-61) [9]**	**49 (43-61) [9]**
1986	**W**	**49 (44-56) [2]**	**49 (44-56) [2]**
1987	**D**	**50 (41-62) [23]**	**51 (41-62) [27]**
1988	**D**	**50 (40-60) [22]**	**50 (40-60) [24]**
1989	**N**	**51 (44-59) [20]**	**50 (44-59) [20]**
1990	**D**	**50 (42-62) [11]**	**50 (42-62) [12]**
1991	**CD**	**51 (44-65) [22]**	**50 (43-65) [22]**
1992	**D**	**51 (40-61) [26]**	**51 (40-60) [19]**
1993	W	49 (42-61) [10]	49 (42-61) [12]
1994	**CD**	**49 (41-61) [14]**	**49 (41-61) [15]**
1995	**EW**	**49 (41-55) [0]**	**49 (41-56) [0]**
1996	**W**	**49 (42-59) [11]**	**49 (42-59) [11]**
1997	**W**	**48 (41-57) [1]**	**48 (41-57) [1]**
1998	EW	47 (39-57) [1]	47 (39-57) [1]
1999	W	49 (43-57) [8]	49 (43-57) [8]
2000	**W**	**49 (44-58) [9]**	**49 (44-58) [9]**
2001	**D**	**50 (41-61) [19]**	**50 (41-62) [21]**
2002	**N**	**49 (41-58) [6]**	**50 (41-60) [15]**
2003	**EW**	**NA**	**NA**
Summary of Differences		**Difference in DAT Mean (Range)**	**Difference in No. Exceedances**
Flow Augmentation Years		0.1°F (0.6 to -0.4°F)	+14
Non-Augmentation Years		0°F (0.1 to 0°F)	+2

Notes:

Averages are calculated for a 24-year period for the critical summer and fall reproductive periods for Trinity River spring- and fall-run Chinook Salmon and Coho Salmon

Water temperature management objective for the Trinity River at the North Fork Trinity River confluence for protection of anadromous salmon freshwater life stages is shown for each period.

Years in bold font indicate representative years modeled with augmentation of late-summer flows for Alternative 2.

Key:
CD = critically dry
D = dry
DAT = daily average temperature
EW = extremely wet
N = normal
NCRWQCB = North Coast Regional Water Quality Control Board
W = wet

Pacific Lamprey The temperature requirements and preferences of Pacific Lamprey and other lamprey species inhabiting the Klamath-Trinity River basin tributaries overlaps that of the sympatric anadromous salmonid species, but they are tolerant of somewhat warmer temperatures during the freshwater and reproductive lifestages (Moyle 2002). Given the relative similarity of the water temperatures, with minor differences in magnitude of the ranges in DATs, it is likely

that the effects on Pacific Lampreys and other lamprey species would be similar for Alternative 2 and the No Action Alternative.

Changes in Trinity River Spring Flow Release Patterns

Chinook Salmon, Coho Salmon, and Steelhead Alternative 2 would operate Lewiston Dam releases according to a rescheduling of the Trinity River ROD flow release schedules in all water year types, as described in Chapter 2, "Description of Alternatives." The primary effect of rescheduling Trinity River ROD releases would be an acceleration of the descending limb component of the managed hydrograph in May and June of all water year types, and a reduction in duration of the critically dry year peak flow by about 14 days.

The functional flow-related fish habitat management objectives of the descending limb of the hydrograph vary by water year, but are primarly intended to provide optimal water temperatures (during normal and wetter water years) or suitable to marginal water temperatures (during dry and critically dry water years) for juvenile salmonid growth and survival and a gradual seasonal warming cue, as flows recede, for outmigrating smolts (see Table 7-2). The critically dry year peak flow is intended to inundate the flanks and high ends of alluvial bars and provide non-lethal water temperatures for steelhead and Coho Salmon until the latter half of May. Flow recession rates are intended to provide for a gradual warming of the river and minimize risk of stranding of salmon fry in side-channels and upper bar and floodplain areas.

Habitat availability high up on alluvial bars that is used by juvenile salmonids for rearing, particularly fry, would be reduced under Alternative 2 compared to the No Action Alternative, for about two weeks in critically dry years. Flow recession rates during the descending limb of the hydrograph would be somewhat faster in all years, but would remain gradual enough to allow for fish to move from side-channels and off-channel areas into the main river channel as flow declines.

Changes in Trinity River Water Temperatures During Spring Flow Releases

Chinook Salmon, Coho Salmon, and Steelhead The potential changes to water temperatures during the spring/early-summer in the Trinity River, below Lewiston Dam to its confluence with the Klamath River at Weitchpec, under Alternative 2 compared to the No Action Alternative would be different from that of Alternative 1, because Alternative 2 includes rescheduling the spring/early summer component of the Trinity River ROD flow release schedule to provide additional late-summer flow releases from Lewiston Dam. This operation would reduce flows more rapidly in the spring and early summer, which could affect water temperatures throughout the length of the river.

The mean and range of DATs during the spring/early-summer period at the North Fork Trinity River confluence (on downstream to Weitchpec) are somewhat higher for Alternative 2 compared to the No Action Alternative (Tables 7-17 and 7-18), particularly during critically dry years, when the greatest differences from the Trinity River ROD flow schedule would occur. The number of days of additional exceedances of temperature management criteria would increase at the North Fork Trinty River confluence in late May and June, and from mid-April through early-July at Weitchpec, though most of the additional exceedances occur during dry and critically dry years. Maximum differences in DATs between Alternative 2 and the No Action Alternative during periods when exceedances occur could be up to about 3°F at the North Fork Trinity

confluence, and about 2°F at Weitchpec. Optimal and marginally-suitable temperature conditions for juvenile Chinook Salmon, Coho Salmon, and steelhead growth and outmigration survival would be of shorter duration, especially in the lower reaches of the Trinity River during dry and critically dry water years.

Table 7-17. Change in Daily Average Water Temperatures Compared to Spring-Time Temperature Objectives Near the North Fork Trinity River Confluence Under the No Action Alternative and Alternative 2

Year	Water Year Type	4/15 to 5/22 ≤ 55.4° for N, W, & EW ≤ 59°F for D & CD WYs Average; (Range); [# days]		5/23 to 6/4 ≤ 59°F for N, W, & EW ≤ 62.6°F for D, CD Average; (Range); [# days]		6/5 to 7/9 ≤ 62.6°F for N, W, & EW Average; (Range); [# days]	6/5 to 6/15 ≤ 62.6°F for D, CD
		No Action	Alternative 2	No Action	Alternative 2	No Action	Alternative 2
1980	W	51 (47-56) [2]	51 (47-56) [2]	48 (46-51) [0]	48 (46-51) [0]	55 (49-57) [0]	55 (51-57) [0]
1981	**D**	**52 (49-57) [0]**	**53 (49-57) [0]**	**58 (54-60) [0]**	**58 (54-61) [0]**	**60 (57-62) [1]**	**60 (58-62) [1]**
1982	EW	51 (45-53) [0]	51 (45-53) [0]	47 (46-48) [0]	47 (46-48) [0]	52 (47-56) [0]	52 (47-56) [0]
1983	EW	49 (45-56) [1]	49 (45-56) [1]	53 (51-55) [0]	53 (51-54) [0]	55 (52-58) [0]	55 (51-58) [0]
1984	W	51 (47-54) [0]	51 (47-54) [0]	51 (49-53) [0]	51 (49-53) [0]	57 (51-60) [0]	57 (51-60) [0]
1985	**D**	**53 (50-57) [0]**	**53 (50-58) [0]**	**55 (52-57) [0]**	**56 (52-58) [0]**	**61 (56-65) [0]**	**61 (56-66) [1]**
1986	**W**	**50 (46-55) [0]**	**50 (46-55) [0]**	**51 (48-55) [0]**	**51 (48-55) [0]**	**56 (53-58) [0]**	**56 (53-58) [0]**
1987	**D**	**54 (49-60) [1]**	**55 (49-60) [1]**	**56 (53-59) [0]**	**56 (53-59) [0]**	**60 (58-62) [0]**	**60 (58-63) [0]**
1988	**D**	**52 (47-57) [0]**	**52 (47-58) [0]**	**56 (53-58) [0]**	**56 (53-58) [0]**	**55 (51-62) [2]**	**55 (51-62) [3]**
1989	**N**	**52 (49-59) [7]**	**52 (49-59) [7]**	**52 (48-56) [0]**	**53 (48-57) [0]**	**58 (53-59) [0]**	**58 (53-59) [0]**
1990	**D**	**53 (50-58) [0]**	**54 (50-58) [0]**	**52 (49-56) [0]**	**52 (49-56) [0]**	**60 (56-62) [0]**	**60 (56-62) [0]**
1991	**CD**	**54 (49-58) [0]**	**54 (49-59) [0]**	**58 (53-60) [0]**	**60 (55-62) [0]**	**63 (60-65) [0]**	**66 (62-68) [0]**
1992	**D**	**53 (50-58) [0]**	**54 (50-58) [0]**	**59 (55-63) [1]**	**60 (56-64) [2]**	**61 (55-63) [3]**	**61 (56-64) [5]**
1993	W	50 (47-53) [0]	50 (47-53) [0]	49 (48-50) [0]	49 (48-51) [0]	56 (49-59) [0]	56 (49-59) [0]
1994	**CD**	**56 (50-60) [7]**	**56 (50-60) [7]**	**59 (58-61) [0]**	**62 (59-65) [5]**	**60 (56-63) [0]**	**63 (57-66) [0]**
1995	**EW**	**49 (45-53) [0]**	**49 (45-53) [0]**	**48 (48-50) [0]**	**48 (47-49) [0]**	**53 (48-59) [0]**	**53 (48-59) [0]**
1996	**W**	**51 (47-55) [0]**	**51 (47-55) [0]**	**51 (47-54) [0]**	**51 (47-55) [0]**	**57 (53-60) [0]**	**57 (53-60) [0]**
1997	**W**	**52 (47-55) [0]**	**52 (47-55) [0]**	**50 (47-54) [0]**	**50 (47-54) [0]**	**56 (53-58) [0]**	**56 (53-58) [0]**
1998	EW	51 (46-55) [0]	51 (46-55) [0]	48 (45-53) [0]	48 (45-53) [0]	55 (52-57) [0]	55 (53-57) [0]
1999	W	51 (48-56) [3]	51 (48-56) [3]	52 (50-53) [0]	52 (50-53) [0]	56 (52-60) [0]	57 (52-60) [0]
2000	**W**	**51 (47-55) [0]**	**51 (47-55) [0]**	**52 (51-53) [0]**	**52 (51-53) [0]**	**57 (52-60) [0]**	**57 (52-60) [0]**
2001	**D**	**55 (49-60) [3]**	**55 (49-60) [3]**	**59 (57-63) [0]**	**60 (57-63) [1]**	**60 (58-62) [0]**	**60 (58-63) [0]**
2002	**N**	**51 (47-57) [3]**	**51 (47-57) [3]**	**53 (50-57) [0]**	**54 (50-58) [0]**	**57 (55-59) [0]**	**57 (55-59) [0]**
2003	**EW**	**50 (46-53) [0]**	**50 (46-53) [0]**	**49 (48-51) [0]**	**49 (48-51) [0]**	**54 (50-58) [0]**	**54 (51-58) [0]**

Table 7-17. Change in Daily Average Water Temperatures Compared to Spring-Time Temperature Objectives Near the North Fork Trinity River Confluence Under the No Action Alternative and Alternative 2 (contd.)

	4/15 to 5/22		**5/23 to 6/4**		**6/5 to 7/9**	
Summary of Differences	**Difference in DAT Mean (Range)**	**Difference in Number of Exceedances**	**Difference in DAT Mean (Range)**	**Difference in Number of Exceedances**	**Difference in DAT Mean (Range)**	**Difference in Number of Exceedances**
Flow Augmentation	0.2°F (0.5 to 0°F)	0	0.6°F (2.8 to -0.1°F)	+7	0.5°F (2.5 to 0°F)	+4
No Flow Augmentation	0°F (--)	0	0.1°F (0.2 to 0°F)	0	0°F (03 to -0.3°F)	0

Notes:

Averages are calculated for a 24-year period for the critical spring and early summer rearing and outmigration periods for Trinity River anadromous salmonids

Water temperature management objectives for the Trinity River from Lewiston Dam to Weitchpec for protection of anadromous salmon freshwater life stages are shown for each period.

Years in **bold** font indicate representative years modeled with augmentation of late-summer flows for Alternative 1

Key:

CD = critically dry water year
D = dry water year
DAT = daily average temperature
EW = extremely wet water year
N = normal water year
W = wet

Table 7-18. Change in Daily Average Water Temperatures Compared to Spring-Time Temperature Objectives for Lewiston Dam to Weitchpec Under the No Action Alternative and Alternative 2

Year	Water Year Type	4/15 to 5/22 ≤ 55.4° for N, W, & EW ≤ 59°F for D & CD WYs Average; (Range); [# days]		5/23 to 6/4 ≤ 59°F for N, W, & EW ≤ 62.6°F for D, CD Average; (Range); [# days]		6/5 to 7/9 ≤ 62.6°F for N, W, & EW Average; (Range); [# days]	6/5 to 6/15 ≤ 62.6°F for D, CD
		No Action	Alternative 2	No Action	Alternative 2	No Action	Alternative 2
1980	W	55 (51-60) [24]	55 (51-60) [24]	52 (49-55) [0]	52 (49-56) [0]	61 (54-64) [10]	61 (55-64) [10]
1981	**D**	**56 (52-60) [4]**	**56 (53-60) [4]**	**63 (58-66) [8]**	**64 (59-67) [9]**	**65 (62-67) [0]**	**66 (62-67) [0]**
1982	EW	55 (47-58) [23]	55 (47-58) [23]	52 (50-54) [0]	52 (50-54) [0]	59 (51-63) [1]	59 (51-63) [1]
1983	EW	52 (47-61) [7]	52 (47-61) [7]	59 (57-61) [8]	59 (57-61) [8]	61 (58-64) [3]	61 (57-64) [3]
1984	W	53 (50-59) [4]	53 (50-59) [4]	56 (53-59) [0]	57 (53-59) [1]	63 (55-68) [24]	63 (55-68) [24]
1985	**D**	**56 (51-62) [4]**	**56 (51-63) [6]**	**60 (57-62) [0]**	**61 (57-64) [5]**	**67 (61-72) [5]**	**68 (61-72) [5]**
1986	**W**	**53 (50-58) [7]**	**53 (50-58) [7]**	**57 (51-61) [4]**	**57 (51-62) [5]**	**63 (60-65) [20]**	**63 (60-65) [20]**
1987	**D**	**59 (53-64) [18]**	**60 (53-64) [19]**	**61 (57-67) [3]**	**61 (58-67) [3]**	**68 (66-70) [4]**	**69 (67-71) [6]**
1988	**D**	**55 (49-62) [3]**	**56 (49-63) [3]**	**60 (57-64) [2]**	**61 (57-64) [5]**	**58 (55-66) [0]**	**59 (55-65) [0]**
1989	**N**	**57 (52-64) [19]**	**57 (52-64) [19]**	**57 (52-63) [3]**	**57 (52-63) [3]**	**64 (58-66) [30]**	**64 (58-66) [32]**
1990	**D**	**57 (53-62) [9]**	**57 (53-62) [9]**	**54 (53-58) [0]**	**54 (53-58) [0]**	**64 (58-65) [0]**	**64 (58-66) [0]**
1991	**CD**	**56 (52-60) [1]**	**56 (52-61) [1]**	**61 (58-63) [2]**	**62 (60-64) [3]**	**67 (63-69) [4]**	**69 (64-71) [7]**
1992	**D**	**58 (56-62) [10]**	**59 (56-62) [17]**	**65 (60-70) [12]**	**66 (61-70) [12]**	**67 (60-70) [7]**	**68 (61-71) [7]**
1993	W	54 (51-57) [10]	54 (51-57) [10]	55 (54-57) [0]	55 (54-57) [0]	63 (54-66) [23]	63 (54-66) [23]
1994	**CD**	**59 (53-65) [18]**	**60 (53-65) [19]**	**65 (61-66) [12]**	**67 (62-69) [12]**	**66 (62-70) [4]**	**69 (64-72) [7]**
1995	**EW**	**53 (47-58) [5]**	**53 (47-58) [5]**	**54 (53-55) [0]**	**54 (53-55) [0]**	**59 (53-67) [14]**	**59 (53-67) [14]**
1996	**W**	**54 (49-59) [14]**	**54 (49-59) [14]**	**55 (52-60) [1]**	**55 (52-60) [1]**	**63 (59-67) [20]**	**63 (59-67) [20]**
1997	**W**	**57 (52-62) [28]**	**57 (52-62) [28]**	**54 (51-59) [1]**	**55 (51-59) [1]**	**62 (57-65) [16]**	**62 (58-65) [16]**
1998	EW	55 (47-60) [18]	55 (47-60) [18]	51 (47-57) [0]	51 (47-57) [0]	61 (57-65) [5]	61 (57-65) [6]
1999	W	54 (49-60) [10]	54 (49-60) [10]	58 (55-59) [2]	58 (56-59) [3]	62 (55-66) [20]	62 (55-66) [23]
2000	**W**	**54 (50-57) [8]**	**54 (50-57) [8]**	**57 (55-58) [0]**	**57 (55-58) [0]**	**63 (58-67)[20]**	**63 (58-67) [20]**
2001	**D**	**58 (52-65) [13]**	**58 (52-66) [15]**	**65 (63-67) [13]**	**66 (64-68) [13]**	**65 (63-68) [0]**	**66 (64-69) [0]**
2002	**N**	**54 (51-60) [12]**	**54 (51-60) [12]**	**59 (54-62) [6]**	**59 (54-63) [6]**	**64 (61-66) [30]**	**64 (61-66) [32]**
2003	**EW**	**52 (48-55) [0]**	**52 (48-55) [0]**	**54 (52-56) [0]**	**54 (52-56) [0]**	**60 (55-65) [12]**	**60 (56-65) [13]**

Table 7-18. Change in Daily Average Water Temperatures Compared to Spring-Time Temperature Objectives for Lewiston Dam to Weitchpec under the No Action Alternative and Alternative 2 (contd.)

	4/15 to 5/22		**5/23 to 6/4**		**6/5 to 7/9**	
Summary of Differences	**Difference in DAT Mean (Range)**	**Difference in Number of Exceedances**	**Difference in DAT Mean (Range)**	**Difference in Number of Exceedances**	**Difference in DAT Mean (Range)**	**Difference in Number of Exceedances**
Flow Augmentation	0.2°F (0.5 to 0°F)	+13	0.5°F (2.2 to 0°F)	+10	0.5°F (2.4 to 0°F)	+13
No Flow Augmentation	0°F (--)	0	0.1°F (0.2 to 0°F)	+2	0.1°F (0.2 to -0.2°F)	+4

Notes:

Averages are calculated for a 24-year period for the critical spring and early summer rearing and outmigration periods for Trinity River anadromous salmonids

Water temperature management objectives for the Trinity River from Lewiston Dam to Weitchpec for protection of anadromous salmon freshwater life stages are shown for each period.

Years in **bold** font indicate representative years modeled with augmentation of late-summer flows for Alternative 1

Key:

CD = critically dry water year
D = dry water year
DAT = daily average temperature
EW = extremely wet water year
N = normal water year
W = wet

Pacific Lamprey The temperature requirements and preferences of Pacific Lamprey and other lamprey species inhabiting the Klamath-Trinity River basin tributaries overlaps that of the sympatric anadromous salmonid species, but is generally somewhat broader during the freshwater and reproductive lifestages (Moyle 2002). Therfore, effects of Alternative 2 on lamprey compared to the No Action Alternative would be similar or less than those described for anadromous salmonids.

Changes in Late Summer Flows in the Lower Klamath River Below the Trinity River Confluence

Chinook Salmon, Coho Salmon, and Steelhead Alternative 2 would release additional late-summer flows from Lewiston Dam on the Trinity River to augment flows in the lower Klamath River, to reduce the potential risk and severity of Ich infection and epizootics that could lead to fish die-offs, in a manner similar to that described for Alternative 1. The same preventative base flow of 2,800 cfs, and the preventative and emergency pulse flows of 5,000 cfs, would be achieved under Alternative 2. Accordingly, the same potential to affect conditions that result in some level of reduced risk of Ich infection, epizootic outbreaks and consequent fish die-offs could occur under Alternative 2. These include: increases in cross-sectional channel area to expand habitat space, increased water velocities that can reduce efficacy of Ich parasites from finding and attaching to adult salmon hosts, and potentially provide migration cues to further disperse adult salmon and reduce densities in the lower Klamath River. In addition, reduction in the frequency of year-to-year parasite carryover effect may be reduced.

Pacific Lamprey Although, Pacific Lamprey may migrate into the Klamath River from spring through summer, few are thought to reside in the lower Klamath River during the late-summer. No lampreys were reported among the fish that died in the 2002 mass fish mortality event (DFG 2004). The effects on Pacific Lamprey of Alternative 2, compared to the No Action Alternative, are thought to be negligible.

Green Sturgeon Green Sturgeon, including both northern DPS that spawn in the Klamath and Trinity Rivers, and southern DPS that may move into the Klamath River estuary to forage, may occur in the lower Klamath River during the late-summer. Some Green Sturgeon were reported among the fish that died in the 2002 mass fish mortality event (DFG 2004). The effects on Green Sturgeon of Alternative 2, compared to the No Action Alternative, are thought to be of potentially similar benefit as for the anadromous salmonids.

Eulachon It is unclear whether this species has been extirpated from the Klamath River. However, Eulachon are reported to spawn in the lower Klamath River, up to 7 miles inland, during March through May, with the larvae washing out through the estuary to the ocean by June. Therefore, increased late-summer flows in the lower Klamath River would not affect Eulachon.

Changes in Late Summer Water Temperatures in the Lower Klamath River Below the Trinity River Confluence

Chinook Salmon, Coho Salmon, and Steelhead Alternative 2 would result in similar reductions in the mean and range of DAT and 7DADM during the late-summer flow augmentation releases from Lewiston Dam over the period from August 22 to September 22 in the lower Klamath River at the head of estuary (RM 5.7) and near the Blue Creek confluence (RM 16.5) (Tables 7-19 and

7-20). Given the reduction in number of days when modeled DATs would exceed the thermal barrier threshold temperature, and the reduction in 7DADM during late-summer flow augmentation in the lower Klamath River, thermal risk factors contributing to the potential for and severity of Ich infection would be reduced to some degree under Alternative 2 similar to Alternative 1, as compared to the No Action Alternative.

Table 7-19. Changes in Maximum 7-Day Average of Daily Maximum Water Temperatures on the Lower Klamath River near Klamath, California, Under the No Action Alternative and Alternative 2

Year	**Water Year Type**	**No Action**		**Alternative 2**	
		DAT Statistics Average; (Range); [# days]	**Maximum 7DADM (°F)**	**DAT Statistics Average; (Range); [# days]**	**Maximum 7DADM (°F)**
1980	W	68 (63-71) [0]	73	68 (63-71) [0]	73
1981	**D**	**70 (62-73) [0]**	**74**	**67 (62-70) [0]**	**73**
1982	EW	68 (62-74) [3]	75	68 (62-74) [3]	75
1983	EW	68 (64-70) [0]	74	68 (64-70) [0]	74
1984	W	69 (62-72) [0]	74	69 (62-72) [0]	74
1985	**D**	**66 (62-73) [0]**	**74**	**66 (62-73) [0]**	**74**
1986	**W**	**67 (58-74) [1]**	**75**	**67 (58-74) [1]**	**74**
1987	**D**	**68 (64-77) [5]**	**76**	**66 (61-71) [0]**	**72**
1988	**D**	**70 (62-75) [12]**	**76**	**66 (61-72) [0]**	**74**
1989	**N**	**68 (63-71) [0]**	**75**	**67 (63-69) [0]**	**74**
1990	**D**	**69 (66-71) [0]**	**73**	**68 (65-70) [0]**	**73**
1991	**CD**	**72 (68-76) [10]**	**76**	**68 (65-71) [0]**	**74**
1992	**D**	**70 (67-74) [1]**	**76**	**66 (61-69) [0]**	**73**
1993	W	69 (63-72) [0]	73	69 (63-72) [0]	73
1994	**CD**	**70 (66-74) [3]**	**76**	**64 (60-67) [0]**	**72**
1995	**EW**	**69 (67-71) [0]**	**73**	**69 (67-71) [0]**	**73**
1996	**W**	**68 (63-74) [1]**	**75**	**68 (63-74) [1]**	**75**
1997	**W**	**69 (64-72) [0]**	**74**	**69 (64-72) [0]**	**74**
1998	EW	70 (64-75) [4]	75	70 (64-75) [4]	75
1999	W	69 (66-74) [5]	75	69 (66-74) [5]	75
2000	**W**	**68 (64-73) [0]**	**74**	**68 (64-73) [0]**	**74**
2001	**D**	**70 (66-72) [0]**	**74**	**66 (63-69) [0]**	**73**
2002	**N**	**69 (65-74) [3]**	**75**	**64 (58-69) [0]**	**71**
2003	**EW**	**69 (63-73) [4]**	**76**	**67 (62-73) [1]**	**75**
Summary of Differences	**Difference in DAT Mean (Range)**		**Difference in 7DADM Mean (Range)**		**Difference in Number of Exceedances**
Flow Augmentation Years	-2.1°F (0 to -5.8°F)		-1.4°F (0 to -4.6°F)		-37
Non-Augmentation Years	0°F (--)		0°F (0.1 to 0°F)		0

Notes:
Averages are calculated for a 24-year period during the flow augmentation period, August 22 to September 22.
Daily average water temperatures ≥ 73.4°F have been reported to inhibit migratory behavior of adult salmon.
Years in **bold** font indicate representative years modeled with augmentation of late-summer flows for Alternative 1.
Key:7DADM = 7-day average daily maximum D = dry N = normal W = wet
CD = critically dry EW = extremely wet POR = period of record

Table 7-20. Changes in Maximum 7-Day Average of Daily Maximum Water Temperatures on the Lower Klamath River near Blue Creek Under the No Action Alternative and Alternative 2

		No Action		**Alternative 2**	
Year	**Water Year Type**	**DAT statistics Average; (Range); [# days]**	**Maximum 7DADM (°F)**	**DAT statistics Average; (Range); [# days]**	**Maximum 7DADM (°F)**
1980	W	67 (62-70) [0]	72	67 (62-70) [0]	72
1981	**D**	**69 (62-72) [0]**	**74**	**66 (62-70) [0]**	**73**
1982	EW	68 (62-74) [4]	75	68 (62-74) [4]	75
1983	EW	67 (64-70) [0]	74	67 (64-70) [0]	74
1984	W	69 (61-72) [0]	74	69 (61-72) [0]	74
1985	**D**	**66 (61-73) [1]**	**74**	**66 (61-73) [0]**	**74**
1986	**W**	**67 (58-73) [0]**	**74**	**66 (58-73) [0]**	**73**
1987	**D**	**68 (64-77) [5]**	**76**	**66 (61-72) [0]**	**71**
1988	**D**	**69 (61-74) [3]**	**75**	**65 (60-71) [0]**	**73**
1989	**N**	**68 (62-71) [0]**	**74**	**66 (62-69) [0]**	**73**
1990	**D**	**68 (66-71) [0]**	**73**	**67 (65-70) [0]**	**73**
1991	**CD**	**71 (68-75) [9]**	**76**	**67 (65-70) [0]**	**74**
1992	**D**	**69 (66-74) [3]**	**76**	**65 (60-69) [0]**	**73**
1993	W	68 (62-73) [0]	73	68 (62-73) [0]	73
1994	**CD**	**70 (65-73) [1]**	**75**	**64 (60-67) [0]**	**72**
1995	**EW**	**69 (67-71) [0]**	**73**	**69 (67-71) [0]**	**73**
1996	**W**	**68 (62-74) [1]**	**74**	**68 (62-74) [1]**	**74**
1997	**W**	**68 (63-71) [0]**	**74**	**68 (63-71) [0]**	**74**
1998	EW	70 (64-75) [4]	75	70 (64-75) [4]	75
1999	W	69 (66-74) [3]	75	69 (66-74) [4]	75
2000	**W**	**68 (64-72) [0]**	**73**	**68 (64-72) [0]**	**73**
2001	**D**	**69 (66-72) [0]**	**73**	**66 (62-68) [0]**	**72**
2002	**N**	**69 (65-73) [0]**	**74**	**63 (58-67) [0]**	**71**
2003	**EW**	**69 (63-74) [4]**	**76**	**67 (62-72) [1]**	**75**
Summary of Differences	**Difference in DAT Mean (Range)**		**Difference in 7DADM Mean (Range)**		**Difference in Number of Exceedances**
Flow Augmentation Years	-2.3°F (0 to -6.3°F)		-1.4°F (0 to -4.9°F)		-25
Non-Augmentation Years	0°F (0.1 to 0°F)		0°F (0.1 to 0°F)		+1

Notes:
Averages are calculated for a 24-year period during the flow augmentation period, August 22 to September 22.
Daily average water temperatures ≥ 73.4°F have been reported to inhibit migratory behavior of adult salmon.
Years in **bold** font indicate representative years modeled with augmentation of late-summer flows for Alternative 1.
Key:
7DADM = 7-day average daily maximum
CD = critically dry
D = dry
EW = extremely wet
N = normal
POR = period of record
W = wet

Pacific Lamprey Similar to the previous discussion of effects of late-summer augmentation flows, water temperatures associated with late-summer augmentation flows in the lower Klamath River under Alternative 2, compared to the No Action Alternative, are thought to be negligible for Pacific Lamprey.

Green Sturgeon Similar to the previous discussion of effects of late-summer augmentation flows, water temperatures associated with late-summer augmentation flows in the

lower Klamath River under Alternative 2, compared to the No Action Alternative, are thought to be of potentially similar benefit to Green Sturgeon as for anadromous salmonids.

Eulachon Similar to the previous discussion of effects of late-summer augmentation flows, water temperatures associated with late-summer augmentation flows in the lower Klamath River under Alternative 2, compared to the No Action Alternative, would not affect Eulachon.

Central Valleyand Bay-Delta Region

Fish Habitat Conditions in the CVP and SWP Reservoirs

Changes in Black Bass Nesting Success The analysis of effects associated with changes in operation on reservoir fishes relied on evaluation of changes in available habitat (reservoir elevations) and anticipated changes in black bass nesting success.

Under Alternative 2, reservoir elevations would be similar compared to the No Action Alternative (less than 1 percent difference). Therefore, there would be no change in nesting success for Largemouth Bass, Smallmouth Bass, and Spotted Bass in Whiskeytown Lake, Shasta Lake, Oroville Lake, and Folsom Lake (Tables 7-21 through 7-23). Whiskeytown Reservoir has 100 percent nesting success under all alternatives, in all months for all species, for both the No Action Alternative and Alternative 2.

Table 7-21. Black Bass Nesting Success in Percent Survival in Shasta Reservoir for the No Action Alternative and Alternative 2

	March		April		May		June	
Water Year Type	**No Action**	**Alt 2 (Difference from No Action)**	**No Action**	**Alt 2 (Difference from No Action)**	**No Action**	**Alt 2 (Difference from No Action)**	**No Action**	**Alt 2 (Difference from No Action)**
Largemouth Bass								
Wet	100	0	100	0	100	0	41	0
AN	100	0	100	0	100	0	8	0
BN	100	0	100	0	100	0	7	0
Dry	100	0	100	0	100	0	1	0
Critical	100	0	85	1	50	1	0	0
All Years	100	0	100	0	100	0	9	0
Smallmouth Bass								
Wet	100	0	100	0	100	0	36	0
AN	100	0	100	0	100	0	10	0
BN	100	0	100	0	86	1	8	1
Dry	100	0	100	0	85	0	3	1
Critical	100	0	73	1	43	0	0	0
All Years	100	0	100	0	100	0	9	0
Spotted Bass								
Wet	100	0	100	0	100	0	100	0
AN	100	0	100	0	100	0	61	0
BN	100	0	100	0	100	0	59	1
Dry	100	0	100	0	100	0	51	0
Critical	100	0	100	0	100	0	18	1
All Years	100	0	100	0	100	0	61	0

Key: Alt = Alternative AN = Above Normal BN = Below Normal

Table 7-22. Black Bass Nesting Success in Percent Survival in Oroville Reservoir for the No Action Alternative and Alternative 2

Water Year Type	March		April		May		June	
	No Action	Alt 2 (Difference from No Action)	No Action	Alt 2 (Difference from No Action)	No Action	Alt 2 (Difference from No Action)	No Action	Alt 2 (Difference from No Action)
Largemouth Bass								
Wet	100	0	100	0	100	0	100	0
AN	100	0	100	0	100	0	27	0
BN	100	0	100	0	100	0	0	0
Dry	100	0	100	0	100	0	0	0
Critical	100	0	100	0	100	0	0	0
All Years	100	0	100	0	100	0	9	0
Smallmouth Bass								
Wet	100	0	100	0	100	0	85	0
AN	100	0	100	0	100	0	25	0
BN	100	0	100	0	100	0	3	0
Dry	100	0	100	0	100	0	0	0
Critical	100	0	100	0	92	0	0	0
All Years	100	0	100	0	100	0	10	0
Spotted Bass								
Wet	100	0	100	0	100	0	100	0
AN	100	0	100	0	100	0	87	0
BN	100	0	100	0	100	0	50	0
Dry	100	0	100	0	100	0	13	0
Critical	100	0	100	0	100	0	34	-4
All Years	100	0	100	0	100	0	62	0

Key:
Alt = Alternative
AN = Above Normal
BN = Below Normal

Table 7-23. Black Bass Nesting Success in Percent Survival in Folsom Reservoir for the No Action Alternative and Alternative 2

	March		April		May		June	
Water Year Type	**No Action**	**Alt 2 (Difference from No Action)**	**No Action**	**Alt 2 (Difference from No Action)**	**No Action**	**Alt 2 (Difference from No Action)**	**No Action**	**Alt 2 (Difference from No Action)**
Largemouth Bass								
Wet	100	0	100	0	100	0	100	0
AN	100	0	100	0	100	0	61	0
BN	100	0	100	0	100	0	50	0
Dry	100	0	100	0	100	0	20	0
Critical	100	0	100	0	100	0	22	-1
All Years	100	0	100	0	100	0	52	-1
Smallmouth Bass								
Wet	100	0	100	0	100	0	100	0
AN	100	0	100	0	100	0	53	0
BN	100	0	100	0	100	0	44	0
Dry	100	0	100	0	100	0	19	0
Critical	100	0	100	0	100	0	21	-1
All Years	100	0	100	0	100	0	45	0
Spotted Bass								
Wet	100	0	100	0	100	0	100	0
AN	100	0	100	0	100	0	100	0
BN	100	0	100	0	100	0	100	0
Dry	100	0	100	0	100	0	78	0
Critical	100	0	100	0	100	0	81	-1
All Years	100	0	100	0	100	0	100	0

Key:
Alt = Alternative
AN = Above Normal
BN = Below Normal

Changes in Cold Water Fish Habitat Changes in CVP and SWP water supplies and operations under Alternative 2, as compared to the No Action Alternative, generally would result in similar reservoir storage in CVP and SWP reservoirs in the Central Valley Region. Changes in storage levels in Shasta Lake, Lake Oroville, and Folsom Lake would be less than 1 percent under Alternative 1 compared to the No Action Alternative, as summarized in Chapter 4, "Surface Water Supply and Management." These minimal differences in reservoir storage in all water year types would not result in changes to cold-water fish habitat under Alternative 2 compared to the No Action Alternative.

Aquatic Habitat Conditions in Rivers Downstream from the CVP and SWP Reservoirs

Changes in Juvenile Chinook Salmon Production - SALMOD Output SALMOD results indicate that potential juvenile production under Alternative 1 would be the similar (less than 4 percent difference) to the No Action Alternative in all water year types (Table 7-24).

There are *2* out of 12 critical water years in which production under Alternative 2 decreased by more than 20 percent for fall-run Chinook Salmon relative to the No Action Alternative. The overall average change in critical water years were less than 2 percent, and had an increase in

production by more than 10 percent in 1 critical water year. The overall average smolt production in all water years was just over 2 percent.

Late fall-run Chinook Salmon—and through their similarity, steelhead—experience production decreases by more than 7 percent in 1 out of 12 critical years, and 2 out of 18 dry years, but also increased by more than 5 percent in 1 critical water year. The overall average for critical and dry water years was less than 1 percent, and smolt production in all years averaged less than 1 percent difference from the No Action Alternative

Winter-run Chinook Salmon experience an increase in production by more than 20 percent in 1 critical water year. The overall average difference in critical water years, as well as for all water years, was less than 1 percent compared to the No Action Alternative.

Spring-run Chinook Salmon, which have a very low spawning population in the Sacramento River could experience 100 percent mortality in 1 critical water year, and greater than 25 percent decrease in 2 additional critical years, relative to the No Action Alternative. The modeled production in those years under the No Action Alternative, in two of those three years, consisted of only only 10 and 115 juvenile fish. In 4 critical water years, spring-run Chinook Salmon could experience an increase in production ranging from 11 to 147 percent. Populations of 500 or more spawning Chinook Salmon are considered necessary for accurate results using SALMOD because it is a deterministic model that relies on the “law of large numbers.” When populations are *low* (an arbitrary term), mean responses are quickly affected by environmental stochasticity and individual variability. The overall average difference in smolt production relative to the No Action Alternative was less than 1 percent.

Table 7-24. Juvenile Chinook Salmon Production Based on SALMOD Results for Alternative 2

Water Year Type	No Action Alternative (Average Production)	Alternative 2 (Difference from No Action)	Alternative 2 (Percent Change)
Fall-Run Chinook Salmon			
Critical	13,058,552	-309,976	-2.4
Dry	29,967,217	6,406	0.0
Below Normal	30,112,903	5,401	0.0
Above Normal	30,324,698	-10,254	0.0
Wet	29,159,993	-3,425	0.0
All Water Years	27,275,865	-46,226	-0.2
Late Fall-Run Chinook Salmon			
Critical	5,245,425	-17,793	-0.3
Dry	5,648,977	-31,007	-0.5
Below Normal	5,787,938	-3,483	-0.1
Above Normal	5,929,655	-20,597	-0.3
Wet	5,868,372	1,558	0.0
All Water Years	5,720,957	-13,095	-0.2
Winter-Run Chinook Salmon			
Critical	2,382,579	19,855	0.8
Dry	3,327,324	-2,652	-0.1
Below Normal	3,250,781	-461	0.0
Above Normal	3,149,290	9,195	0.3
Wet	3,139,415	-396	0.0
All Water Years	3,090,275	3,459	-0.1
Spring-Run Chinook Salmon			
Critical	68,168	-83	-0.1
Dry	416,959	1,040	0.2
Below Normal	447,950	-1,818	-0.4
Above Normal	465,691	-453	-0.1
Wet	467,027	-605	-0.1
All Water Years	392,786	-264	-0.1

Changes in Winter-Run Chinook Salmon Production - Interactive Object-Oriented Simulation Output The IOS model predicted adult escapement trajectories for winter-run Chinook Salmon across the 81 simulated years. Under Alternative 2, average adult escapement was 6,729 and under the No Action Alternative, average escapement was 6,793 (Table 7-25). Adult escapement estimates were based on the water year type in the third year previous to the adult return, the assumed time for spawning, rearing and outmigration. Two of 11 critical, 1 of 19 dry, 2 out of 11 above normal, and 4 out of 25 wet water years would experience decreases greater than 5 percent under Alternative 1 relative to the No Action Alternative.

Similar to adult escapement, the IOS model predicted similar (less than 3 percent difference) egg survival, fry-to-smolt survival, smolt production, and survival downstream from RBPP and in the Delta for winter-run Chinook Salmon between Alternative 2 and the No Action Alternative, across the 81 water years (Table 7-25).

Table 7-25. IOS Model Results for Winter-Run Chinook Salmon for Alternative 2

Water Year Type	No Action	Alternative 2	Alternative 2 (Percent Change)
Adult Escapement			
Critical	4,806	4,911	2
Dry	6,772	6,699	-1
Below Normal	5,249	5,274	0
Above Normal	5,426	5,368	-1
Wet	8,887	8,787	-1
All Water Years	6,793	6729	-1
Egg Survival			
Critical	0.55	0.56	0.3
Dry	0.99	0.98	-0.3
Below Normal	0.98	0.98	0.3
Above Normal	0.99	0.99	0.1
Wet	0.99	0.99	-0.1
All Water Years	0.92	0.92	0
Fry-to-Smolt Survival			
Critical	0.48	0.47	-3.0
Dry	0.93	0.93	0.1
Below Normal	0.93	0.93	0.1
Above Normal	0.94	0.94	0.0
Wet	0.93	0.93	0.0
All Water Years	0.87	0.86	-0.2
Smolt Production			
Critical	3,568,552	3,452,638	-3.2
Dry	6,143,220	6,114,900	-0.5
Below Normal	5,329,551	5,360,342	0.6
Above Normal	4,466,911	4,400,987	-1.5
Wet	6,916,239	6,835,961	-1.2
All Water Years	5,600,444	5,545,919	-1.0
Red Bluff Pumping Plant to Delta Survival			
Critical	0.24	0.24	0.0
Dry	0.24	0.24	0.0
Below Normal	0.23	0.23	0.0
Above Normal	0.24	0.24	0.0
Wet	0.23	0.23	0.0
All Water Years	0.23	0.23	0.0
Delta Survival			
Critical	0.32	0.32	0.1
Dry	0.40	0.40	0.0
Below Normal	0.41	0.41	0.1
Above Normal	0.38	0.38	0.0
Wet	0.40	0.40	0.0
All Water Years	0.39	0.39	0.0

Changes in Water Temperature Long-term daily average monthly water temperature in Clear Creek at Igo and in the Sacramento River downstream from Clear Creek, at Balls Ferry, Jellys Ferry, and Bend Bridge under Alternative 2 would generally be similar (less than 0.2°F difference) to water temperatures under the No Action Alternative (See Chapter 5, “Surface Water Quality”).

Overall, the minimal temperature differences between Alternative 2 and the No Action Alternative would have similar effects on all runs of Chinook Salmon, steelhead, and Green Sturgeon in the Sacramento River.

Changes in Exceedances of Water Temperature Thresholds Average monthly water temperatures from April through October under both the No Action Alternative and Alternative 2 exceed the water temperature threshold of 56°F in the Sacramento River below Clear Creek less than 14 percent of the time. In the Sacramento River at Balls Ferry, for winter-run and spring-run Chinook Salmon spawning and egg incubation, the water temperature threshold would be exceeded by 22 percent of the time under both the No Action Alternative and Alternative 2. Water temperature thresholds would be exceeded nearly 40 percent of the critical months under the No Action Alternative and Alternative 2 at Jellys Ferry. At Bend Bridge, the frequency of exceedances would be similar under Alternative 2 and the No Action Alternative (61 percent) of the simulated years. The differences between the No Action Alternative and Alternative 2 are less than 1 percent.

Average monthly water temperatures in Clear Creek at Igo between June and September exceed the 60°F threshold under both the No Action Alternative and Alternative 2 less than 1 percent of the time. The September to October threshold of 56°F would be exceeded by 12 percent under both the No Action Alternative and Alternative 2.

Changes in Weighted Usable Area As described above for the assessment methodology, 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 habitat for winter-run Chinook Salmon, fall-run Chinook Salmon, late fall-run Chinook Salmon, and steelhead between Keswick Dam and Battle Creek, flows in the Sacramento River below Keswick Dam indicate that there is little difference in the amounts of spawning habitat, suitable fry rearing habitat, and suitable juvenile rearing habitat under Alternative 2 and the No Action Alternative (less than 5 percent difference).

Based on the simulated flows, WUA values for spring-run Chinook Salmon, fall-run Chinook Salmon, and steelhead in Clear Creek are similar, with a less than 5 percent difference between Alternative 2 and the No Action Alternative, for spawning habitat, suitable fry rearing habitat, and suitable juvenile rearing habitat.

The amount of suitable spawning habitat, fry rearing habitat, and juvenile rearing habitat would be similar, less than 5 percent difference, between Alternative 1 and the No Action Alternative for fall-run Chinook Salmon and steelhead in the lower Feather River and the lower American River.

Fish Habitat Conditions in Bay-Delta

Changes in Delta Hydrodynamics Under Alternative 2, Delta outflow would be similar (less than 1 percent difference) to the No Action Alternative (See Chapter 4, “Surface Water Supply and Management”).

The OMR flows would be similar in all almost all months between Alternative 2 and the No Action Alternative, with the long-term average ranging from -6,219 to 914 cfs (compared with -6,217,385 to 914 cfs under the No Action Alternative) from December through June under Alternative 2 (See Chapter 4, "Surface Water Supply and Management"). In June of critical water years, there was a 7 percent increase in negative flows (a change from -1,414 cfs under No Action Alternative to -1,514 cfs under Alternative 2). This change, however, is substantially below the -5,000 cfs criteria, and therefore, does not result in an adverse effect to Delta fishes.

As a result, Delta fishes, including Delta Smelt, Longfin Smelt, all runs of Chinook Salmon, steelhead, and Green Sturgeon would not be affected by the implementation of Alternative 2 resulting from a change in Delta hydrodynamics.

Changes in X2 Location Overall, the quantitative results from the numerical models suggest that operations under Alternative 2 would result in a less-than-1 percent change in the X2 location relative to the No Action Alternative in all months and all water year types. Implementing Alternative 2 would not affect fish habitat resulting from the placement of X2.

Summary of Environmental Consequences

Table 7-26 presents the results of the environmental consequences analysis for implementing the action alternatives compared to the No Action Alternative.

Table 7-26. Comparison of Action Alternatives to No Action Alternative

Alternative	Potential Change	Consideration for Mitigation Measures
Alternative 1	**Klamath and Trinity River Region**	
	Trinity River	
	Coho Salmon, Spring-run Chinook Salmon, Fall-run Chinook Salmon, and Steelhead	
	Late Summer Augmentation: Spring-run Chinook Salmon	
	Late-summer augmentation release operations could interrupt or dewater redds of spring-run Chinook Salmon, which may begin spawning in early- to mid-September, before releases are returned to baseflow.	Coordination with resource agencies as part of annual flow augmentation implementation process
	Pulse Flows: Coho Salmon, Spring-run Chinook Salmon, Steelhead	
	Late-summer preventive and emergency pulse flows may be high enough to overtop berms along the river channel, potentially increasing risk of stranding juvenile salmon upon reduction of the pulse flows back to the baseflow. Gradual ramping rates are intended to minimize this risk.	Coordination with resource agencies as part of annual flow augmentation implementation process
	Fall Temperature Objectives: Coho Salmon, Spring-run Chinook Salmon, Fall-run Chinook Salmon, Steelhead	None needed
	Water temperatures meet the temperature objectives in a similar pattern as the No Action Alternative, with the difference in the number of days exceeding the objectives at less than 2%. Spawning and adult migration would not be affected by changes in fall temperatures under Alternative 1.	

Table 7-26. Comparison of Action Alternatives to No Action Alternative (contd.)

Alternative	Potential Change	Consideration for Mitigation Measures
Alternative 1 (contd.)	*Spring Temperature Objectives: Coho Salmon, Spring-run Chinook Salmon, Fall-run Chinook Salmon, Steelhead* Water temperatures in the spring/early-summer (May-June) meet the temperature objectives at all locations in a similar pattern as the No Action Alternative, with the difference in the number of days exceeding the objectives at less than 5%. Juvenile rearing and outmigration would not be affected by changes in the spring water temperatures under Alternative 1. *Alluvial Bar Habitat in the Spring: Coho Salmon, Spring-run Chinook Salmon, Fall-run Chinook Salmon, Steelhead* Rearing habitat availability high up on alluvial bars would be similar to the No Action Alternative *July to September Temperature Objectives: Spring-run Chinook Salmon* Water temperatures between July and mid-September meet the temperature objectives at all locations in a similar pattern as the No Action Alternative, with the difference in the number of days exceeding the objectives less than 1% of the time. Adult holding would not be affected by changes in the spring water temperatures under Alternative 1. *Late Summer Flow Release: Coho Salmon, Steelhead* Additional Lewiston Dam late-summer flow releases, which will extend cooler water temperatures to the confluence, are expected to provide suitable water temperatures for rearing juveniles	None needed
	<u>Pacific Lamprey</u> Increased late-summer augmentation flows may cause increased water velocities and disturbance of fine sediments along the summer baseflow channel where lamprey ammocoetes are living. Because the range of augmentation flows would be within the typical range of annual fluctuations in the upper Trinity River, which lampreys experience over their freshwater juvenile life stage, it is expected that juvenile lampreys will redistribute to other areas of suitable habitat over the course of the augmentation flow cycle, if disturbed by higher water velocities.	None needed
	<u>Reservoir Fishes</u> Reservoir fish habitat for both cold and warm water (e.g., black bass) fishes in Trinity Lake would be similar to the No Action Alternative.	None needed

Table 7-26. Comparison of Action Alternatives to No Action Alternative (contd.)

Alternative	Potential Change	Consideration for Mitigation Measures
Alternative 1 (contd.)	***Lower Klamath River*** <u>Coho Salmon, Spring-run and Fall-run Chinook Salmon, Steelhead, Pacific Lamprey</u> The risk of Ich infection epizootic events, and fish die-offs would be reduced compared to the No Action Alternative through increased habitat area, increased water velocities, improved migration cues, and a decrease in frequency of water temperatures exceeding 73.4°F.	None needed
	<u>Eulachon</u> Effects to flows in the lower Klamath River and Estuary would be similar between Alternative 1 and the No Action Alternative.	None needed
	Central Valley and Bay-Delta Region	
	<u>Chinook Salmon and Steelhead</u> SALMOD results indicate some critical years may result in decreased production of Chinook compared with the No Action Alternative. Overall averages show similar production levels (less than 3%) for all runs of Chinook Salmon (and through similar life stages, steelhead), except for fall-run Chinook which experience a higher potential mortality rate in critical water years, averaging 6% reduced survival and spring-run, which experience a greater than 5% increase in survival in critical water years.	Reclamation will consult with fisheries agencies consistent with the 2009 NMFS BO RPAs and coordinate with resource agencies
	IOS results indicate winter-run Chinook Salmon would experience reduced survival during several critical water years, resulting in a less than 1% average reduction in spawning escapement, a 9% reduction in fry-to-smolt survival and 5% reduction in smolt production under Alternative 1. However, the average overall affects to winter-run Chinook salmon are similar, with a less than 1% reduction in spawning escapement to the No Action Alternative.	Reclamation will consult with fisheries agencies consistent with the 2009 NMFS BO RPAs and coordinate with resource agencies
	Water temperatures would be generally similar at compliance locations in the upper Sacramento River under Alternative 1 compared to the No Action Alternative except in some critical water years in the Sacramento River below Clear Creek, Balls Ferry, and Jellys Ferry. Water temperature thresholds for spawning and incubation in the Sacramento River would be met similarly between the Alternative 1 and the No Action Alternative, with differences of less than, or equal to, 1%. The number of times the temperature thresholds are exceeded increases as the water flows downstream, but the changes in exceedence between the No Action Alternative and Alternative 1 remain generally similar (less than 1%). The WUA in the Sacramento, Feather and American Rivers and Clear Creek for Chinook Salmon and steelhead spawning, fry rearing, and juvenile rearing would be generally similar (less than 1% change) for suitable habitat to the No Action Alternative. The Delta hydrodynamics (outflow, X2, OMR reverse flows) would be generally similar between Alternative 1 and the No Action Alternative. This would result in similar levels of entrainment between the No Action Alternative and Alternative 1.	None needed

Table 7-26. Comparison of Action Alternatives to No Action Alternative (contd.)

Alternative	Potential Change	Consideration for Mitigation Measures
Alternative 1 (contd.)	<u>Green Sturgeon</u> Water temperatures would be generally similar at compliance locations in the upper Sacramento River under Alternative 1 compared to the No Action Alternative. Water temperature thresholds for Green Sturgeon in the Sacramento River would be met similarly between Alternative 1 and the No Action Alternative, with differences of less than or equal to 1%. The number of times the temperature thresholds are exceeded increases as the water flows downstream, but the changes in exceedence between the No Action Alternative and Alternative 1 remain generally similar (less than 1% difference). The Delta hydrodynamics would be generally similar between Alternative 1 and the No Action Alternative. This would result in similar levels of entrainment of Green Sturgeon between the No Action Alternative and Alternative 1.	None needed
	<u>Delta Smelt and Longfin Smelt</u> The Delta hydrodynamics would be generally similar between Alternative 1 and the No Action Alternative. This would result in similar levels of entrainment of Delta Smelt between the No Action Alternative and Alternative 1.	None needed
	<u>Reservoir Fishes</u> There would be similar reservoir fish habitat conditions (less than 1% change) for cold water fishes from a change in storage in Whiskeytown Lake, Shasta Lake, Oroville Lake and Folsom Lake. Black bass nesting success would be similar (less than 1% difference) between Alternative 1 and the No Action Alternative in Whiskeytown Lake, Shasta Lake, Oroville Lake and Folsom Lake.	None needed
Alternative 2	**Klamath and Trinity River Region**	
	Trinity River <u>Coho Salmon, Spring-run Chinook Salmon, Fall-run Chinook Salmon, and Steelhead</u> *Pulse Flows: Coho Salmon, Spring-run Chinook Salmon, Steelhead* Late-summer preventive and emergency pulse flows may be high enough to overtop berms along the river channel, potentially increasing risk of stranding juvenile salmon upon reduction of the pulse flows back to the baseflow. Gradual ramping rates are intended to minimize this risk. *Late Summer Augmentation: Spring-run Chinook Salmon* Late-summer augmentation release operations could interrupt or dewater redds of spring-run Chinook Salmon, which may begin spawning in early- to mid-September, before releases are returned to baseflow.	None needed

Table 7-26. Comparison of Action Alternatives to No Action Alternative (contd.)

Alternative	Potential Change	Consideration for Mitigation Measures
Alternative 2 (contd.)	Coho Salmon, Spring-run Chinook Salmon, Fall-run Chinook Salmon, and Steelhead *Fall Temperature Objectives: Coho Salmon, Spring-run Chinook Salmon, Fall-run Chinook Salmon, Steelhead* Water temperatures meet the temperature objectives in a similar pattern as the No Action Alternative, with the difference in the number of days exceeding the objectives at less than 2%. Spawning and adult migration would not be affected by changes in fall temperatures under Alternative 2. *Spring Temperature Objectives: Coho Salmon, Spring-run Chinook Salmon, Fall-run Chinook Salmon, Steelhead* Water temperatures in the spring/early-summer (May-June) meet the temperature objectives at all locations in a similar pattern as the No Action Alternative, with the difference in the number of days exceeding the objectives at less than 5%. Juvenile rearing and outmigration would not be affected by changes in the spring water temperatures under Alternative 2. Maximum differences between Alternative 2 and the No Action Alternative during periods when exceedances occur could be up to 3°F at the North Fork Trinity confluence and about 2°F at Weitchpec. *Alluvial Bar Habitat in the Spring: Coho Salmon, Spring-run Chinook Salmon, Fall-run Chinook Salmon, Steelhead* Habitat availability high up on alluvial bars used by fry and juvenile salmonids for rearing would be similar to the No Action Alternative, except for about two weeks during May and June in critically dry years. Low recession rates would remain gradual enough to allow for fish to move from side-channels and off-channel areas into the main river channel as flow decline. *July to Mid-September Temperature Objectives: Spring-run Chinook Salmon* Water temperatures between July and mid-September meet the temperature objectives at all locations in a similar pattern as the No Action Alternative, with the difference in the number of days exceeding the objectives less than 1% of the time. Adult holding would not be affected by changes in the spring water temperatures under Alternative 2.	None needed

Table 7-26. Comparison of Action Alternatives to No Action Alternative (contd.)

Alternative	Potential Change	Consideration for Mitigation Measures
Alternative 2 (contd.)	*Late Summer Flow Release: Coho Salmon, Steelhead* Additional Lewiston Dam late-summer flow releases, which will extend cooler water temperatures to the confluence, are expected to provide suitable water temperatures for rearing juveniles	None needed
	Pacific Lamprey Increased late-summer augmentation flows may cause increased water velocities and disturbance of fine sediments along the summer baseflow channel where lamprey ammocoetes are living. Because the range of augmentation flows would be within the typical range of annual fluctuations in the upper Trinity River, which lampreys experience over their freshwater juvenile life stage, it is expected that juvenile lampreys will redistribute to other areas of suitable habitat over the course of the augmentation flow cycle, if disturbed by higher water velocities.	None needed
	Reservoir Fishes Black bass nesting success is slightly higher under Alternative 2 compared to the No Action Alternative.	None needed
	Lower Klamath River	
	Coho Salmon, Spring-run and Fall-run Chinook Salmon, Steelhead, Pacific Lamprey The risk of Ich infection, epizootic events, and fish die-offs would be reduced compared to the No Action Alternative through increased habitat area, increased water velocities, improved migration cues, and a decrease in frequency of water temperatures exceeding 73.4°F.	None needed
	Eulachon Affects to flows in the lower Klamath River and Estuary would be similar between Alternative 2 and the No Action Alternative.	None needed
	Central Valley and Bay-Delta Region	
	Chinook Salmon and Steelhead SALMOD results indicate some critical years may result in decreased production of Chinook Salmon compared with the No Action Alternative, however, the overall averages show similar production levels (less than 3% reduction) for all four runs of Chinook Salmon (and through similar life stages, steelhead). IOS results indicate winter-run Chinook Salmon would experience reduced survival during several critical water years, but the overall spawning escapement in critical water years would increase by about 2%. The average overall affects to winter-run Chinook salmon are similar with a less than 1% reduction in spawning escapement to the No Action Alternative.	None needed

Table 7-26. Comparison of Action Alternatives to No Action Alternative (contd.)

Alternative	Potential Change	Consideration for Mitigation Measures
Alternative 2 (contd.)	Water temperatures would be generally similar at compliance locations in the upper Sacramento River under Alternative 2 compared to the No Action Alternative. Water temperature thresholds for spawning and incubation in the Sacramento River would be met similarly between the Alternative 2 and the No Action Alternative, with differences of less than or equal to 1%. The number of times the temperature thresholds are exceeded increases as the water flows downstream, but the changes in exceedence between the No Action Alternative and Alternative 2 remain generally similar (less than 1% difference). The WUA in the Sacramento, Feather and American Rivers and Clear Creek for Chinook Salmon and steelhead spawning, fry rearing, and juvenile would be generally similar (less than 1% change) for suitable habitat to the No Action Alternative. The Delta hydrodynamics would be generally similar between Alternative 2 and the No Action Alternative. This would result in similar levels of entrainment between the No Action Alternative and Alternative 2.	
	<u>Green Sturgeon</u> Water temperatures would be generally similar (less than 0.5ºF) at compliance locations in the upper Sacramento River under Alternative 2 compared to the No Action Alternative. Water temperature thresholds for Green Sturgeon in the Sacramento River would be met similarly between Alternative 2 and the No Action Alternative, with differences of less than, or equal to, 1%. The number of times the temperature thresholds are exceeded increases as the water flows downstream, but the changes in exceedence between the No Action Alternative and Alternative 2 remain generally similar (less than 1% difference). The Delta hydrodynamics (outflow, X2, OMR reverse flows) would be generally similar between Alternative 2 and the No Action Alternative. This would result in similar levels of entrainment of Green Sturgeon between the No Action Alternative and Alternative 2.	None needed
	<u>Delta Smelt and Longfin Smelt</u> The Delta hydrodynamics (outflow, X2, OMR reverse flows) would be generally similar between Alternative 2 and the No Action Alternative. This would result in similar levels of entrainment of Delta Smelt between the No Action Alternative and Alternative 2.	None needed
	<u>Reservoir Fishes</u> There would be similar reservoir fish habitat conditions (less than 1% change) for cold water fishes from a change in storage in Whiskeytown Lake, Shasta Lake, Oroville Lake and Folsom Lake between Alternative 2 and the No Action Alternative.	None needed

Key:
°F = degrees Fahrenheit
% = percent
cfs = cubic feet per second
OMR = Old and Middle River

Potential Mitigation Measures

Mitigation measures have not been identified for Central Valley Chinook Salmon. The analyses for Alternative 1 showed reduced survival of early life stages of winter-run (up to 9 percent) and fall-run Chinook Salmon smolt production (up to 6 percent). These effects would be minimized through implementation of the consultation procedures required by the 2009 NMFS BO, or through coordination with resource agencies on real-time operations.

Cumulative Effects Analysis

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 action alternatives for fisheries is summarized in Table 7-27. The methodology for this cumulative effects analysis is described in the Cumulative Effects Technical Appendix.

Table 7-27. Summary of Cumulative Effects on Fish Resources of Action Alternatives as Compared to the No Action Alternative

Scenarios	Cumulative Effects of Actions
No Action Alternative with Associated Cumulative Effects Actions in Year 2030	*Conditions and Actions Included in Quantitative Analyses* *(Conditions and actions incorporated into No Action Alternative modeling)* For Klamath Basin rivers, reduced snowpack due to climate change would shift flow patterns to an earlier and shorter spring runoff period, reducing flows during summer months. During summer months, lower flows and increased temperature conditions, due to increased ambient temperatures, would likely increase the potential for Ich epizootic events and related fish die-offs. For the Central Valley and Delta, climate change and sea-level rise, development under the general plans, FERC relicensing projects, and some future projects to improve water quality or habitat are anticipated to reduce carryover storage in reservoirs, stream flows and Delta outflow as compared to past conditions. These future actions could modify surface water conditions (e.g., flow and water temperature) and affect habitat for fish and aquatic resources. *Additional Identified Actions* *(Additional reasonably foreseeable projects or actions identified in Cumulative Effects Technical Appendix)* Within the Klamath River Basin, additional reasonably foreseeable actions including the Klamath River Main Stem Dam Removal and Hoopa Valley Tribe Watershed Restoration Projects are anticipated to improve or increase available fish habitat. Within the Central Valley, additional reasonably foreseeable actions (e.g., FERC relicensing projects) could improve aquatic resources in some streams, if stream habitat restoration, fish passage and improved water temperature control result from the FERC process.
Alternative 1 with Associated Cumulative Effects Actions in Year 2030	*Alternative 1 with Conditions and Actions Included in Quantitative Analyses* Implementation of Alternative 1 would result in similar fish habitat conditions during most months and water year types as compared to the No Action Alternative in the Klamath River Basin. During flow augmentation actions in August and September, particurlarly in drier years, Alternative 1 would result in improved conditions on the lower Klamath River, reducing the likelihood of an Ich epizootic event. Implementation of Alternative 1 would result in similar fish habitat conditions during most months and water year types as compared to the No Action Alternative in the Central Valley, except during some critical water years, in which warmer water temperatures may affect Chinook salmon and steelhead. *Alternative 1 with Additional Identified Actions* Alternative 1 with the additional reasonably foreseeable actions would result in beneficial effects to fish habitat conditions in the Klamath Basin, and therefore cumulative effects to fish habitat conditions are not anticipated. Additional reasonably foreseeable actions are not anticipated to result in cumulative effects to fish habitat in the Central Valley.

Table 7-27. Summary of Cumulative Effects on Fish Resources of Action Alternatives as Compared to the No Action Alternative (contd.)

Scenarios	Cumulative Effects of Actions
Alternative 2 with Associated Cumulative Effects Actions in Year 2030	*Alternative 2 with Conditions and Actions included in Quantitative Analyses* Implementation of Alternative 2 would result in similar fish habitat conditions during most months and water year types as compared to the No Action Alternative in the Klamath River Basin. During flow augmentation actions in August and September, particurlarly in drier years, Alternative 2 would result in improved conditions on the lower Klamath River, reducing the likelihood of an Ich epizootic event. Implementation of Alternative 2 would result in similar fish habitat conditions as compared to the No Action Alternative in the Central Valley. *Alternative 2 with Additional Identified Actions* Alternative 2 with the additional reasonably foreseeable actions would result in beneficial effects to fish habitat conditions in the Klamath Basin, and therefore cumulative effects to fish habitat conditions are not anticipated. Additional reasonably foreseeable actions are not anticipated to result in cumulative effects to fish habitat in the Central Valley.

Key:
FERC = Federal Energy Regulatory Commission

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Chapter 8
Biological Resources – Terrestrial

Introduction

This chapter describes the terrestrial biological resources in the study area and potential changes that could occur as a result of implementing the alternatives to augment flows in the lower Klamath River evaluated in this Environmental Impact Statement (EIS). Implementation of the alternatives could affect terrestrial resources by altering the ecological attributes of plant communities and habitat of terrestrial wildlife.

Regulatory Environment and Compliance Requirements

Federal regulations relevant to implementation of the alternatives evaluated in this EIS for terrestrial resources include:

- **Endangered Species Act** – The Federal Endangered Species Act (ESA) applies to proposed Federal, state, and local projects that may result in the "take" of a fish or wildlife species that is federally listed as threatened or endangered and to actions that are proposed to be authorized, funded, or undertaken by a Federal agency and that may jeopardize the continued existence of any federally listed fish, wildlife, or plant species or which may adversely modify or destroy designated critical habitat for such species.

Affected Environment

This section describes terrestrial biological resources that could potentially be directly or indirectly affected by implementing the action alternatives considered in this EIS. These changes may occur in the Lower Klamath and Trinity River Region defined as the Trinity River below Lewiston Dam, the Klamath River below its confluence with the Trinity River, and Trinity Lake and Lewiston Reservoir, and the Sacramento Valley and Bay-Delta Region defined as the Sacramento Valley north of the confluence of the San Joaquin and Sacramento Rivers and the Sacramento-San Joaquin River Delta (Delta). Terrestrial biological resources occur throughout these regions. However, the terrestrial biological resources that could be affected are located within or related to specific areas: 1) along the shorelines and riparian zone of Trinity Lake and Lewiston Reservoir and other reservoirs that store Central Valley Project (CVP) and State Water Project (SWP) water supplies, 2) along the shoreline and riparian zone of Trinity River downstream from Lewiston Dam and the Klamath River from its confluence with Trinity River to the ocean and along other rivers and waterways (including Yolo Bypass and other flood bypasses) downstream from CVP or SWP reservoirs, 3) wildlife refuges that receive CVP water supplies, 4) wetlands

and riparian corridors within the Delta and Suisun Marsh, and 5) within agricultural acreage that is irrigated with CVP and SWP water supplies.

The following description of the affected environment is limited to the above described areas. An analysis of storage and water level changes in New Melones, Millerton and San Luis reservoirs and the San Joaquin and Stanislaus Rivers (per CalSim II; please see *Impact Analysis* below in this chapter, and Chapter 4, "Surface Water Supply and Management") indicates no difference in water surface elevation on these reservoirs would occur in any month under either action alternative compared to the No Action Alternative. Also, no change in flow in these rivers would occur in any month under either action alternative compared to the No Action Alternative. Therefore, descriptions of affected environment for these reservoirs and for the Stanislaus and San Joaquin Rivers, and analysis of potential changes to terrestrial biological resources for these facilities, are not further examined in this EIS.

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 may be affected by implementation of the alternatives is provided in Biological Resources – Terrestrial Technical Appendix. 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 Office.

To supplement the USFWS lists, the California Natural Diversity Database (CNDDB) was queried (DFG 2012) for regions where recent documentation was lacking. This included the Trinity River Region, including Trinity Lake, Lewiston Reservoir, Whiskeytown Lake, and Clear Creek between Carr Powerhouse and the Sacramento River confluence.

Critical Habitat

Critical habitat refers to areas designated by the USFWS for the conservation of species listed as threatened or endangered under 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 implementation of the alternatives considered in this EIS are presented in Table 8-1 below. There are occurrences of critical habitat of other species not included in Table 8-1 or other locations of critical habitat of the species listed in Table 8-1 which are not included below because those occurrences are not located within the areas that could be

affected by implementation of the alternatives, such as lands located at high elevations within national forests where CVP and SWP water is not delivered.

Table 8-1. Terrestrial Species with Designated Critical Habitat in Portions of the Study Area that Could Be Affected by the Action Alternatives

Species	Regions	Counties
Valley Elderberry Longhorn Beetle	Sacramento Valley and Delta	Sacramento
Yellow-billed cuckoo	Sacramento Valley and Delta	Butte, Colusa, Glenn, Sutter
Soft Bird's-Beak	Sacramento Valley and Delta	Solano
Suisun Thistle	Sacramento Valley and Delta	Solano
Antioch Dunes evening-primrose	Sacramento Valley and Delta	Sacramento

Source: USFWS 2016

Lower Klamath and Trinity River Region

For the Lower Klamath and Trinity River Region, the scope of analysis within this chapter is limited to the Trinity River from Lewiston Dam to its confluence with the Klamath River, the Klamath River from Trinity River to the Pacific Ocean, and Trinity Lake and Lewiston Reservoir.

Trinity River and Klamath River

This chapter's scope of analysis within the Lower Klamath and Trinity River Region includes the shorelines, riparian zone and wetted perimeter of the Trinity River from Trinity Lake to the confluence with the Klamath River; and the shorelines, riparian zone and wetted perimeter of the lower Klamath River from the confluence with the Trinity River to the Pacific Ocean. The scope of analysis also includes Trinity Lake and Lewiston Reservoir and their shorelines and riparian zones.

The Trinity River system downstream from Lewiston Reservoir includes the mainstem, North Fork Trinity River, South Fork Trinity River, New River, and numerous smaller streams (NCRWQCB et al. 2009; USFWS et al. 2000). Trinity Lake and Lewiston Reservoir are located upstream from the confluences of the Trinity River with the North Fork, South Fork, and New River. However, these tributaries are not affected by implementing the alternatives considered in this EIS. The Trinity River flows approximately 112 miles from Lewiston Reservoir to the Klamath River through Trinity and Humboldt counties and the Hoopa Valley 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. 2000). Downstream from the Trinity River confluence, the Klamath River flows through Humboldt and Del Norte counties and through the Hoopa Valley 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 from the confluence with the Trinity River. The Klamath River estuary extends approximately 5 miles upstream from 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.

Trinity Lake and Lewiston Reservoir

The dominant vegetation community in the Trinity River watershed upstream from Lewiston Reservoir includes mixed conifer, with Ponderosa Pine (*Pinus ponderosa*), Sugar Pine (*Pinus lambertiana*), and Douglas Fir (*Pseudotsuga menziesii*) as the dominant species. Some south-facing slopes are dominated by oak (*Quercus* spp.) and brush. Mixed hardwood communities occur at lower elevations, and include species such as Pacific Madrone (*Arbutus menziesii*), Big-Leaf Maple (*Acer macrophyllum*), and a variety of oaks. The shrub community at lower elevations includes a number of chaparral plants such as manzanitas (*Arctostaphylos* spp.), Bitterbrush (*Purshia tridentata*), and Deerbrush (*Ceanothus integerrimus*). South-facing slopes around Trinity Lake contain shrub fields that provide winter range for the Weaverville deer (*Odocoileus* spp.) herd (USFS 2005; STNF 2014)

Along some 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 largely constrained by fluctuating water levels and steep banks, particularly on Trinity Lake (NCRWQCB et al. 2009; USFWS et al. 2000).

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 Bald Eagle (*Haliaeetus leucocephalus*) and other raptors that prey on fish (e.g., Osprey [*Pandion haliaetus*]) and waterfowl.

Recently, ten pairs of mating bald eagles were observed at Trinity Lake and three pairs at Lewiston Lake (USFS 2012).

Trinity River from Lewiston Reservoir to Klamath River

Terrestrial habitat along the Trinity River below Trinity and Lewiston dams has changed since construction of the dams. The ongoing Trinity River Restoration Program (TRRP) is restoring portions of the habitat below Lewiston Dam. The following description reflects recent habitat changes along the mainstem of the Trinity River between Lewiston Reservoir and the confluence of the Klamath River.

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. 2000). 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 encouraged encroachment and maturation of woody vegetation along narrow bands bordering the stabilized channel essentially locking it in place. In addition, the extent of wetlands probably declined following dam construction due, in part, to reduced flows and elimination of river meanders.

The ongoing TRRP includes specific minimum instream flows, as described in Chapter 4, “Surface Water Supply and Management”; mechanical channel rehabilitation; fine and coarse sediment management; watershed restoration; infrastructure improvement; and adaptive management components (NCRWQCB et al. 2009; USFWS and Hoopa Valley Tribe 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 that confined the river. Following removal of the berms and floodplain restoration, some 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. 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 mechanical restoration actions are occurring between Lewiston Dam and the North Fork.

Terrestrial Habitat Despite the removal of certain riparian vegetation areas resulting from TRRP channel widening projects, the riparian corridor of the Trinity River from Lewiston Dam to the North Fork has remained nearly constant in size between 2003, when TRRP channel rehabilitation projects were initiated, and 2014 (TRRP 2015). In 2003, before TRRP channel widening projects were undertaken, riparian vegetation covered 979.3 acres. Riparian vegetation in 2014 was mapped at 970.1 acres. 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. 2000). 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 present prior to dam construction still inhabit the riverine and riparian habitats of the lower 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. 2000). For example, Western Pond Turtle (*Emys marmorata*) declined since completion of the dams in response to diminishing instream habitat. In contrast, species such as Northern Goshawk (*Accipiter gentilis*) and Black Salamander (*Aneides flavipunctatus*) that favor mature, late-successional riparian habitats increased with more upland habitat along the narrow riparian corridor.

Current habitats along the Trinity River between Lewiston Dam and the Klamath 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 species (*Avena* spp.), Soft Brome (*Bromus hordeaceus*), Ripgut Brome (*Bromus diandrus*), Cheatgrass (*Bromus tectorum*), and Barley [*Hordeum vulgare*]); forbs (e.g., Broadleaf Filaree (*Erodium botrys*), California Poppy (*Eschschia californica*), and Bur Clover [*Medicago polymorpha*]); and native perennial species (e.g., Creeping Wildrye [*Leymus triticoides*]). The annual grassland habitat supports Mourning Dove (*Zenaida macroura*), Savannah Sparrow (*Passerculus sandwichensis*), White-Crowned Sparrow (*Zonotrichia leucophrys*), American Kestrel (*Falco sparverius*), Red-Tailed Hawk (*Buteo jamaicensis*), Coyote (*Canis latrans*), California Ground Squirrel (*Otospermophilus beecheyi*), Botta's Pocket Gopher (*Thomomys bottae*), California Kangaroo Rat (*Dipodomys californicus*), Gopher Snake (*Pituophis catenifer*), Northwestern Fence Lizard (*Sceloporus occidentalis* ssp. *occidentalis*), Western Skink

(*Plestiodon skiltonianus*), Northern Pacific Rattlesnake (*Crotalus oreganus oreganus*), and Western Yellow-Bellied Racer (*Coluber constrictor* ssp. *mormon*). The fresh emergent wetland species occur along the backwater areas, depressions, and along the river edges, including Common Tule (*Schoenoplectus acutus* var. *occidentalis*), Narrow-Leaved Cattail (*Typha angustifolia*), Dense Sedge (*Carex densa*), Rye Grass (*Festuca perennis*), Himalayan Blackberry (*Rubus armeniacus*), and Narrow-Leaved Willow (*Salix exigua*). Wildlife species along the fresh emergent wetland include Western Toad (*Anaxyrus boreas*), Pacific Treefrog (*Pseudacris regilla*), American Bullfrog (*Lithobates catesbeianus*), Green Heron (*Butorides virescens*), Mallard (*Anas platyrhynchos*), and Red-Winged Blackbird (*Agelaius phoeniceus*). The montane riparian habitat adjacent to the river include trees, such as Big Leaf Maple, White Alder (*Alnus rhombifolia*), Oregon Ash (*Fraxinus latifolia*), Black Cottonwood (*Populus trichocarpa*), and Goodding's Black Willow (*Salix gooddingii*); and understory species, including Mugwort (*Artemisia* spp.), Western Virgin's Bower (*Clematis ligusticifolia*), American Dogwood (*Cornus sericea*), Oregon Golden-Aster (*Heterotheca oregona*), Dalmatian Toadflax (*Linaria dalmatica* ssp. *dalmatica*), White Sweet Clover (*Meliloyus albus*), Musk Monkeyflower (*Mimulus moschatus*), Straggly Gooseberry (*Ribes divariatum* var. *pubiflorum*), California Wild Grape (*Vitis californica*), and California Blackberry *(Rubus ursinus)*. The valley-foothill riparian habitat occur along alluvial fans, slightly dissected terraces, and floodplains; and include cottonwood species (*Populus* spp.), Western Sycamore (*Platanus racemosa*), Valley Oak (*Quercus lobata*), White Alder, Box Elder (*Acer negundo*), Oregon Ash (*Fraxinus latifolia*), California Wild Grape, California Wild Rose (*Rosa californica*), California Blackberry, Blue Elderberry (*Sambucus nigra*), Western Poison Oak (*Toxicodendron diversilobum*), button bush (*Cephalanthus* spp.), willow species (*Salix* spp.), sedges (*Carex* spp.), rushes (*Juncus* spp.), Miner's Lettuce (*Claytonia perfoliata*), and various grasses. Riparian woodlands along the montane riparian habitat support breeding, foraging, and roosting habitat for Tree Swallow (*Tachycineta bicolor*), Bushtit (*Psaltriparus minimus*), White-Breasted Nuthatch (*Sitta carolinensis*), Nuttall's Woodpecker (*Picoides nuttallii*), Downy Woodpecker (*Picoides pubescens*), Spotted Towhee (*Pipilo maculatus*), and Song Sparrow (*Melospiza melodia*); cover for amphibians, including Western Toad and Pacific Treefrog; and habitat for Deer Mouse, Raccoon (*Procyon lotor*), and Virginia Opossum (*Didelphis virginiana*). The riverine habitat supports amphibians and reptiles, including Western Toad, Pacific Treefrog, and American Bullfrog; birds, including Mallard, Great Blue Heron (*Ardea herodias*), Osprey, and Belted Kingfisher (*Megaceryle alcyon*); and mammals, including Northern River Otter (*Lontra canadensis*), American Beaver (*Castor canadensis*), Big Brown Bat (*Eptesicus fuscus*), and Yuma Myotis (*Myotis yumanensis*).

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, Big Leaf Maple, Canyon Live Oak (*Quercus chrysolepis*), California Black Oak (*Quercus kelloggii*), Blue Oak (*Quercus douglasii*), Ponderosa Pine, Douglas Fir, and Incense Cedar (*Calocedrus decurrens*). Shrubs include Greenleaf Manzanita (*Arctostaphylos patula*), Buckbrush (*Ceanothus cuneatus*), Cascara (*Frangula purshiana*), Snowberry (*Symphoricarpos albus*), and Western Poison Oak. Underlying herbaceous vegetation includes Ripgut Brome, Blue Wild Rye (*Elymus glaucus*), Silver Bush Lupine (*Lupinus albifrons*), Purple Sanicle (*Sanicula bipinnatifida*), and California Hedge-Parsley (*Yabea microcarpa*). The habitats support numerous birds, including Northern Flicker (*Colaptes auratus*), Steller's Jay (*Cyanocitta stelleri*), Hairy Woodpecker (*Picoides villosus*),

Acorn Woodpecker (*Melanerpes formicivorous*), Wrentit (*Chamaea fasciata*), Bewick's Wren (*Thryomanes bewickii*), California Quail (*Callipepla california*), Mountain Quail (*Oreortyx pictus*), Blue Grouse (*Dendragapus obscurus*), Sharp-Shinned Hawk (*Accipiter striatus*), Red-Tailed Hawk, and Great Horned Owl (*Bubo virginianus*); mammals including Black-Tailed Deer (*Odocoileus hemionus* ssp. *columbianus*), Gray Fox (*Urocyon cinereoargenteus*), Coyote, Black-Tailed Jackrabbit (*Lepus californicus*), Raccoon, Virginia Opossum, Western Spotted Skunk (*Spilogale gracilis*), Western Gray Squirrel (*Sciurus griseus*), Allen's Chipmunk (*Tamias senex*), Deer Mouse, and Pallid Bat (*Antrozous pallidus*); and reptiles and amphibians, including California Kingsnake (*Lampropeltis californiae*), Northern Pacific Rattlesnake, Sharp-Tailed Snake (*Contia* sp.), Northwestern Fence Lizard, Southern Alligator Lizard (*Elgaria multicarinata*), and Ensatina (*Ensatina eschscholtzii*).

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).

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; the river slows 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 (*Alnus rubra*). Red Alder is a typical hardwood in riparian zones, Tanoak (*Notholithocarpus densiflorus*) 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 (*Typha* spp.), tules (*Schoenoplectus* spp.), and a variety of rushes and sedges. As the river nears the ocean, salt-tolerant plants such as cord grass (*Spartina* spp.) and pickleweed (*Salicornia* spp.) increase in abundance as the salinity increases (USFWS et al. 2000). Wildlife species in the lower Klamath River watershed are similar to those found in the Trinity River watershed.

Sacramento Valley and Bay-Delta Region

For the Sacramento Valley and Bay-Delta Region, the scope of analysis within this chapter is limited to the Sacramento Valley below Shasta Dam and includes the Delta, Suisun Marsh, and the Yolo Bypass, and the rivers which feed into the Sacramento River below CVP/SWP dams. The scope of analysis also includes Shasta Lake, Whiskeytown Lake, Lewiston Reservoir, and other CVP and SWP reservoirs on river systems within the Sacramento Valley, and agricultural lands and wildlife refuges served by CVP and SWP water supplies within the Sacramento Valley and the Delta. The areas where terrestrial biological resources could potentially be affected

include the fluctuation zones, associated riparian zones, and open water areas of the reservoirs; the shorelines, riparian zone and open water areas of the rivers and the shorelines, riparian zone and surface water of waterways within the Bay-Delta.

The Sacramento Valley and Bay-Delta 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 San Joaquin Valley to the south. Communities of various sizes and an extensive network of roadways are located throughout the valley.

Land use within the Sacramento 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 Valley. 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.

Overview of Terrestrial Communities

This section describes the terrestrial communities in the Sacramento Valley and Bay-Delta Region that could be affected directly or indirectly by implementation of the alternatives considered in this EIS. These communities are broadly described for lakes/reservoirs (including open water and drawdown areas); rivers (including open water and riparian and floodplain areas); wetlands; wildlife refuges and agricultural lands.

Lake/Reservoir Communities Reservoirs potentially affected by implementation of the alternatives considered in this EIS 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 4, “Surface Water Supply and Management,” 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 Northern River Otter and American Beaver. Bald Eagle and Osprey 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 Sacramento Valley and Bay-Delta Region 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 4, “Surface Water Supply and Management,” 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 may slightly increase for piscivorous (fish-eating) birds foraging in the reservoirs as these species may have to travel greater distances to forage (DWR 2004a).

Riverine Communities The primary components of the rivers and streams that support plants and wildlife potentially influenced by implementation of the alternatives under this EIS, including open water areas and adjacent riparian and floodplain communities, are described below.

Open Water Areas The riverine environment downstream from 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. Various gulls and terns, 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 Northern River Otter, American Mink (*Neovison vison*), Common Muskrat (*Ondatra zibethicus*), and American Beaver.

Riparian and Floodplain Areas The riparian and floodplain communities that could be affected by implementation of the alternatives considered in this EIS 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 Sacramento Valley has been reduced over time due to a variety of actions, including local, State, and Federal construction and operation of flood control facilities; 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).

Characteristic riparian tree species in the Sacramento Valley include willows, cottonwoods, California Sycamore, and Valley Oak. Typical understory plants include elderberry species, California and Himalayan Blackberry, and Western 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 Oak 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 (sometimes 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 Valley lacks 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 (*Mephitis mephitis*), Raccoon, and Gray Fox. Riparian bird species include Red-Shouldered Hawk (*Buteo lineatus*), Wood Duck (*Aix sponsa*), Great Blue Heron, Black-Crowned Night Heron (*Nycticorax nycticorax*), and many neotropical migratory birds, including Yellow Warbler (*Setophaga petechia*). Amphibians and reptiles include Pacific Treefrog, Pacific Gopher Snake, and Common Gartersnake (*Thamnophis sirtalis*). Special status species that associate with riparian and floodplain habitats include Bank Swallow (*Riparia riparia*), Western Yellow-Billed Cuckoo (*Coccyzus americanus*), and the Valley Elderberry Longhorn Beetle (*Desmocerus californicus* ssp. *dimorphus*).

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.

Riparian and floodplain communities are anticipated to change along levees within the federally authorized levee systems that have maintenance agreements with the USACE including Delta levees along the Sacramento River and other levees that are eligible for the Federal Rehabilitation and Inspection Program (Public Law 84-99). 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, or enhance natural resources, 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. The California Department of Water Resources (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 in the *Impacts Analysis* section of this chapter under the heading *Changes in Floodplains and Associated Wetlands of Sacramento River and Tributaries and the Delta*.

Wetlands, Marshes, and Wet Meadows Wetlands in the Sacramento 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 River, 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 (NWR) Complex, and around the Thermalito Afterbay (Reclamation 2010). Both tidal and nontidal, perennial wetlands are found in the Delta and Suisun Marsh.

Perennial Non-tidal (Freshwater) Wetlands and Marshes In the Sacramento Valley 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 USACE jurisdiction under Sections 401 and 404 of the Federal Clean Water Act.

Perennial freshwater wetlands are among the most productive wildlife habitats in California (DFG 1988). In the Sacramento Valley 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 Valley 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 (*Eryngium vaseyi*), Toad Rush (*Juncus bufonius*), Hyssop Loosestrife (*Lythrum hyssopifolia*), and Foothill Meadowfoam (*Limnanthes douglasii* ssp. *rosea*). 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 2010).

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 NWR, and Suisun Marsh.

Perennial Tidal Wetlands and Open Water In the Sacramento 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.

Agricultural Lands Agricultural land uses and farming practices in the Sacramento 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 Valley 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 Valley include grain and seed crops (e.g., rice, corn and wheat), forage crops (e.g., hay and alfalfa), row crops (e.g., tomatoes), orchards (e.g., almonds, walnuts, peaches, plums, olives, pears, apricots), and vineyards. There are also areas of irrigated pastureland throughout the Sacramento Valley.

Most of the value for wildlife of grain and seed crops 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 (*Grus Canadensis*). 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 (*Microtus californicus*) and Western Harvest Mouse (*Reithrodontomys megalotis*). 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 (*Sturnella neglecta*), 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 (*Buteo swainsoni*), Northern Harrier (*Circus cyaneus*), Red-Tailed Hawk, and White-Tailed Kite (*Elanus leucurus*).

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, and swallows, bats, and many types of waterfowl and other migratory birds feed on insects in alfalfa fields. Mammals such as gophers, mice, and rabbits feed directly on alfalfa. Larger herbivorous mammals, such as Mule Deer (*Odocoileus hemionus*) and Black-tailed Deer, Pronghorn Antelope (*Antilocapra americana*), and Tule Elk (*Cervus canadensis nannodes*), frequent alfalfa fields, especially during dry or cold seasons. Raptors, migratory birds, Coyote, and Mountain Lion (*Puma concolor*) feed on the birds and rodents that feed on the alfalfa. Scavengers such as Coyote and Turkey Vulture (*Cathartes aura*) also feed on carrion (Putnam et al. 2001).

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. Other wildlife species that use flooded rice fields include Giant Gartersnake (*Thamnophis gigas*) and American Bullfrog. Ring-Necked Pheasant (*Phasianus colchicus*) and Sandhill Crane 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 and wading birds.

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 (*Aphelocoma californica*), American Crow (*Corvus brachyrhynchos*), Plain Titmouse (*Baeolophus*), Brewer's Blackbird (*Euphagus cyanocephalus*), House Finch (*Haemorhous mexicanus*), Western Gray Squirrel and California Ground Squirrel (DFG 1999a, 1999b, 1999c). Other fruit crops such as peaches, apricots, plums, olives, pears and prunes are also eaten by these same species and others such as Band-Tailed Pigeon (*Patagioenas fasciata*), Yellow-Billed Magpie (*Pica nuttalli*), Western Bluebird (*Sialia mexicana*), American Robin (*Turdus migratorius*), Varied Thrush (*Ixoreus naevius*), Northern Mockingbird (*Mimus polyglottos*), Cedar Waxwing (*Bombycilla cedrorum*), Yellow-Rumped Warbler (*Setophaga coronata*), Black-Headed Grosbeak (*Pheucticus melanocephalus*), Bullock's Oriole (*Icterus bullockii*), Cottontail (*Sylvilagus* spp.), Gray Squirrel, Coyote, Black Bear (*Ursus americanus*), Raccoon, and Mule Deer. Olive orchards 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.

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 Greater 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 Mule Deer and Tule 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 gopher, and Burrowing Owl (*Athene cunicularia*). Pastures provide foraging habitat for grassland-foraging wildlife, such as Coyote and Red Fox (*Vulpes vulpes*), 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, which is frequently associated with the water conveyance systems that support rice cultivation.

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 (Cal-IPC 2006).

According to the CDFW'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.

Implementation of the alternatives considered in this EIS could affect the shorelines and riparian zone of reservoirs that store CVP and SWP water supplies within the Klamath and Sacramento and Bay-Delta Regions as defined above in this chapter, and shorelines and riparian zone of rivers downstream from the CVP and SWP reservoirs. Therefore, only those invasive plant species that are associated with the shorelines and riparian zone at these reservoirs and waterways would be likely to cause adverse effects on terrestrial biological resources. Examples of these invasive species include Tree-of-Heaven (*Ailanthus altissima*), Giant Reed (*Arundo donax*), Purple Loosestrife (*Lythrum salicaria*), Perennial Pepperweed (*Lepidium latifolium*), Tamarisk (*Tamarix*), and Red Sesbania (*Sesbania herbacea*).

Sacramento Valley

The Sacramento Valley portion of the Sacramento Valley and Bay-Delta Region considered in this chapter includes Shasta Lake, Keswick Reservoir, and the Sacramento River from Keswick Reservoir to the Delta. This portion also includes the lower Yuba River and the middle and lower portions of the Feather River and American River watersheds that may be influenced by alteration of CVP and SWP operations pursuant to the alternatives considered by this EIS.

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.

Shasta Lake and Keswick Reservoir The Shasta Lake area is characterized by a variety of vegetation and wildlife habitats typical of transitional mixed woodland and low-elevation forest

habitats (Reclamation 2013). 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's shoreline, 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 2013). 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 Coyote and skunk species, and cavities in mature trees are used by cavity-dwelling species such as the Acorn Woodpecker and Californian Myotis (*Myotis californicus*). Many amphibians and reptiles, including Ensatina, Western Skink, and Northwestern Fence Lizard, inhabit the detrital layer of moist areas. Snakes, including the Northern Pacific 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. Northern River Otter, Gray Fox, Coyote, Bobcat (*Lynx rufus*), and Osprey 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 oaks, Gray Pine (*Pinus sabiniana*), Ponderosa Pine, and Douglas-fir trees occur on the foothills above the reservoir. As described in Chapter 4, "Surface Water Supply and Management," water elevations in Keswick Reservoir are relatively stable throughout the year.

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 species, White Alder (*Alnus rhombifolia*), dogwoods (*Cornus* spp.), Oregon Ash (*Fraxinus latifolia*), Big Leaf Maple, and Fremont (*Populus fremontii*) and Black Cottonwood (*Populus trichocarpa*). Wild Grape is also very common; other riparian shrubs include Snowberry, California Blackberry, Toyon (*Heteromeles arbutifolia*), California Buckeye (*Aesculus californica***)** and California Button Willow (*Cephalanthus occidentalis*). 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 from 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).

Sacramento River: Keswick Reservoir to the Delta Controlled flow releases 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 4, "Surface Water Supply and Management." 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 2013).

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 2013). 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 2013). 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 are valuable 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 2013). 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 2013). 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 from Colusa, the Sacramento River channel changes from a dynamic and active meandering one to an artificially confined, narrow channel (Reclamation 2013). 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.

Feather River Lake Oroville and Thermalito Forebay and Afterbay; and the lower Feather River are features of the Feather River watershed that could be affected by implementation of the alternatives considered in this EIS.

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 from 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 from 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 Western Sycamore (*Platanus racemosa*). 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 (*Branta canadensis*), Canyon Wren (*Catherpes mexicanus*), American Dipper (*Cinclus mexicanus*), Killdeer (*Charadrius vociferus*), Mallard, Common Merganser (*Mergus merganser*), and Northern Rough-winged Swallow (*Stelgidopteryx serripennis*).

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 (*Hirundo rustica*), Black Phoebe (*Sayornis nigricans*), White-tailed Kite, Black-tailed Jackrabbit, Brown-headed Cowbird (*Molothrus ater*), American Bullfrog, Common Garternake, Common Yellowthroat (*Geothlypis trichas*), Gopher Snake, Northern Harrier, Pacific Treefrog, Raccoon, Red-winged Blackbird, Ring-necked Pheasant, Short-eared Owl (*Asio flammeus*), Striped Skunk, Tree Swallow (*Tachycineta bicolor*), Virginia Opossum, and Violet-green Swallow (*Tachycineta thalassina*) (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 (*Himantopus mexicanus*), Black Tern (*Chlidonias niger*), California Gull (*Larus californicus*), Caspian Tern (*Hydroprogne caspia*), Forster's Tern (*Sterna forsteri*), Greater Yellowlegs (*Tringa melanoleuca*), Least Sandpiper (*Calidris minutilla*), Long-billed Dowitcher (*Limnodromus scolopaceus*), Ring-billed Gull (*Larus delawarensis*), Semipalmated Sandpiper (*Calidris pusilla*), Spotted Sandpiper (*Actitus macularius*), and White-faced Ibis (*Plegadis chihi*). 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 Snake 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 exists 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 species, Boxelder, White Alder, and Oregon Ash. The riparian strip along the river is bordered mostly by agricultural fields. Downstream from Yuba City near the confluence with the Sacramento River, Valley Oak and Fremont Cottonwood riparian stands become more common.

As described above for the Sacramento River, riparian areas of the Feather River system provide value for wildlife and support a wide range of species of birds, mammals, reptiles, amphibians, and invertebrates.

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 from Folsom Lake. Lake Natoma is located downstream from Folsom Lake. Water continues to flow between Nimbus Dam and the confluence with the Sacramento River, as described in Chapter 4, "Surface Water Supply and Management."

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 2005). Lake Natoma, which serves as an afterbay downstream from 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 (*Accipiter cooperii*), Great Horned Owl, and Long-eared Owl (*Asio otus*) use oak woodlands for nesting, foraging, and roosting. Mammal species likely to occur in woodland habitats include deer, Coyote, Bobcat, Red Fox, Virginia Opossum, Raccoon, rabbits, squirrels, and a variety of other rodents. Amphibians and reptiles that may be found in oak woodlands include California Newt (*Taricha torosa*), Pacific Treefrog, Northwestern Fence Lizard, Gopher Snake, Caliornia Kingsnake, and Northern Pacific Rattlesnake. The adjacent grasslands are used by various bird species for foraging, including White-Crowned Sparrow, Lesser Goldfinch (*Spinus psaltria*), 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 rearing habitat. These species include Pacific Treefrog, Western Toad, Common Garter Snake, American Beaver, Raccoon, and Common Muskrat (*Ondatra zibethicus*).

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 2005). 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 2005).

Lower American River between Lake Natoma and Confluence with the Sacramento River
Downstream from 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 from 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 from 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 species, Western Poison Oak, Wild Grape, Himalayan Blackberry, Northern California Black Walnut (*Juglans californica*), 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. Interior 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 Striped Skunk, Raccoon, Western Gray Squirrel, vole, Common Muskrat, deer, Red Fox, and Coyote. Reptiles and amphibians that occupy riparian habitats along the river include Western Toad, Pacific Treefrog, American Bullfrog, Northwestern Fence Lizard, Common Garter Snake, and Gopher Snake (Reclamation 2005).

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 2005; Reclamation et al. 2006). Plant species that dominate these backwater areas include various species of willow, sedges, cattail, Bulrush, and Rushes. Riparian vegetation around these ponded areas is composed of mixed-age willow, alder, and cottonwoods. 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 (*Podilymbus podiceps*), American Bittern (*Botaurus lentiginosus*), Green Heron, Common Merganser, White-tailed Kite, Wood Duck (*Aix sponsa*), Yellow Warbler, Warbling Vireo (*Vireo gilvus*), Dusky-footed Woodrat (*Neotoma fuscipes*), Western Gray Squirrel, Pacific Treefrog, 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 (*Triadica sebifera*), Giant Reed (*Arundo donax*), Pampas Grass (*Cortaderia selloana*), Spanish Broom (*Spartium junceum*), Himalayan Blackberry, and Tamarisk (*Tamarix* spp.), which can rapidly colonize exposed bar surfaces and stream banks.

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 11, "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 similar to those described in subsection titled *Agricultural Lands in the Delta, Suisun Marsh and Yolo Bypass* below in this chapter.

Wildlife Refuges in the Sacramento Valley The Sacramento Valley supported three major landscape types: wetlands, grassland-prairies, and riparian woodlands (Reclamation et al 2001). 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 [Pacific Flyway Council 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 Peregrine Falcon (*Falco peregrinus*), Bald Eagle, Canada Goose, and California Tiger Salamander (*Ambystoma californiense*).

The Sacramento 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 2013). 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 2011). 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 wading birds, and shorebirds. 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 (*Echinochloa* spp.), Sprangletop (*Leptochloa fusca*), and Smartweed (*Persicaria* spp.). During these irrigation periods, these units are often used by locally nesting colonial wading birds (e.g., 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 Double-crested Cormorant (*Phalacrocorax auritus*.) and American White Pelican (*Pelecanus erythrorhynchos*). 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 (*Agelaius tricolor*).

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, wading birds, 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.

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 from 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 from the confluence between the Sacramento and Feather Rivers to the confluence of Cache Slough and the Sacramento River in the Delta upstream from Rio Vista and Suisun Marsh. The Delta and Suisun Marsh have a complex web of channels and islands and are located at the confluence of the Sacramento and San Joaquin Rivers. As further described below, 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 2009).

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 and 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 2009).

The Delta was once composed of extensive freshwater and brackish marshes, with tules and cattails, broad riparian thickets of scrub willows, California Button Willow, 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 (*Quercus agrifolia*) 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 (*Xanthium strumarium*), Dallis Grass (*Paspalum dilatatum*), Bermuda Grass (*Cynodon dactylon*), Barnyard Grass (*Echinochloa* spp.), and Rye Grass.

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 Salt Grass (*Distichlis spicata*), Alkali Weed (*Cressa truxillensis*), Saltbush (*Atriplex* spp.), Alkali Heath (*Frankenia salina*), and Iodine Bush (*Allenrolfea occidentalis*). 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 (*Isolepis cernua*), common reed (*Phragmites australis*), and cattails. The low tidal wetland zone provides foraging habitat for waterfowl and shorebirds, including California Ridgway's Rail (*Rallus longirostris obsoletus*), California Black Rail (*Laterallus jamaicensis coturniculus*), 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, Salt Grass (*Distichlis spicata*), and bulrush. Other species occurring in the middle tidal marsh are Fleshy Jaumea (*Jaumea carnosa*), Sea Milkwort (*Lysimachia maritima*), rushes, Salt Marsh Dodder (*Cuscuta salina*), Alkali Heath,

cattails, Sneezeweed (*Helenium* spp.), and Marsh Gumplant (*Grindelia stricta* var. *angustifolia*) (Siegel et al. 2010b). The middle tidal wetland zone provides foraging habitat for Salt-Marsh Harvest Mouse (*Reithrodontomys raviventris*) and Suisun Shrew (*Sorex ornatus sinuosus*), 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 (*Melospiza melodia* ssp. *maxillaris*) and Salt Marsh Common Yellowthroat (*Geothlypis trichas* ssp. *sinuosa*) (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 Salt Grass, Pickleweed, and Baltic Rush (*Juncus balticus*), and nonnative species, including Perennial Pepperweed, Poison Hemlock (*Conium maculatum*), and Fennel (*Foeniculum vulgare*). Other species occurring in the high tidal marsh are Salt Marsh Dodder, Fleshy Jaumea, Seaside Arrow-Grass (*Triglochin concinna*), Alkali Heath, Brass-Button (*Cotula coronopifolia*), and rabbitsfoot grass (*Polypogon* spp.).

The high tidal marsh provides habitat for special status plants, including Suisun Marsh Aster (*Symphyotrichum lentum*), Soft Bird’s Beak (*Chloropyron molle* ssp. *molle*), and Suisun Thistle (*Cirsium hydrophilum* var. *hydrophilum*) (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 (*Atriplex prostrata*), and Brass-buttons are typical in the higher elevations of the managed wetlands. In marshes with higher soil salinity, pickleweed, Salt Grass, and other salt-tolerant species are dominant. Managed wetlands are managed specifically as habitat for wintering waterfowl species, including Northern Pintail (*Anas acuta*), Mallard, American Wigeon (*Anas americana*), Green-Winged Teal (*Anas crecca*), Northern Shoveler (*Anas clypeata*), Gadwall (*Anas strepera*), Cinnamon Teal (*Anas cyanoptera*), Ruddy Duck (*Oxyura jamaicensis*), and Canvasback (*Aythya valisineria*) ducks; Greater White-Fronted Goose (*Anser albifrons*), 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 here. Valley Oak and Northern California 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, Himalayan Blackberry, button bush, Mule Fat, 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 (*Passerina amoena*), and Valley Elderberry Longhorn Beetle.

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 4, "Surface Water Supply and Management," the Yolo Bypass generally extends north to south from Fremont Weir along the Sacramento River (near Verona) to upstream from 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 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 species, Eucalyptus (*Eucalyptus*), Giant Reed, and Black Oak. The understory is typically sparse in this community with limited areas of California Grape, Himalayan Blackberry, Western Poison Oak, Mugwort, grasses, and forbs. The woodland canopy provides habitat for hawks, owls, American Crow (*Corvus brachyrhynchos*), Great Egret, Great Blue Heron, White-tailed Kite, Yellow-rumped Warbler (*Setophaga coronata*), Black Phoebe, woodpeckers, Wood Duck, bats, 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 Sacramento Valley. The species include Alders, Elderberry, Fremont Cottonwood, California Wild Rose, Himalayan Blackberry, and Boxelder. This habitat supports Black-Crowned Night Heron, Snowy Egret (*Egretta thula*), Belted Kingfisher, Black Phoebe and Swallow species. Riparian scrub habitat frequently occurs adjacent to non-woody riparian habitat, including Giant Reed (*Arundo donax*), Cocklebur, weedy annual grasses, sedges, rushes, mustards (*Brassica* spp.), Sweet Clover (*Melilotus* spp.), thistles (*Cirsium* spp.), and other weedy species. The non-woody riparian habitat supports Savannah Sparrow, House Finch (*Haemorhous mexicanus*), American Goldfinch (*Spinus tristis*), California Ground Squirrel, and Gopher Snake.

Remnants of Valley Oak woodlands and savanna occur on floodplain terraces in fragmented areas, including downstream from Fremont Weir and along the southern portion of the Toe Drain (CALFED et al. 2001). The habitat also includes Sycamore, Black Walnut, Wild Grape, Western Poison Oak, Elderberry, Himalayan Blackberry, grasses, and sedges.

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 out 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 wading birds, rails, and raptors, and Muskrat, Raccoon, Virginia Opossum, Beaver, Ring-necked Pheasant, Pacific Treefrog, and American 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, Common Water Hyacinth (*Eichhornia crassipes*). 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 (*Crypsis schoenoides*), Watergrass, Smartweed, and Cocklebur. These plants are then managed through the timing, duration or absence of summer irrigation. The mudflats support many species of 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 (*Aythya* spp.), and goldeneye (*Bucephala* spp.); and other water birds, including Pied-Billed Grebe. 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 Great and Snowy egrets.

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.

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 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).

Wildlife Refuges in the Delta, Suisun Marsh, and Yolo Bypass A number of wildlife areas that could be affected by implementation of the alternatives considered in this EIS 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 surrounded by an approximately 9,000-acre "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 range of mammals, birds, reptiles, and amphibians similar to those described for other sections of the Sacramento Valley (USFWS 2007). The grasslands, pastures, and woodlands support White-Faced Ibis, Geese, Black-bellied Plover (*Pluvialis squatarola*), 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 (*Tyto alba*), Bald Eagle, Golden Eagle, American Kestrel, Prairie Falcon (*Falco mexicanus*), Tree Swallow, Barn Swallow, Cliff Swallow (*Petrochelidon pyrrhonota*), 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 (*Cygnus columbianus*), Greater White-fronted Goose, Snow Goose (*Chen caerulescens*), 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, American Coot, cormorant (*Phalacrocorax* spp.), and American White Pelican (*Pelecanus erythrorhynchos*). Other wildlife species on this refuge include Coyote, Deer Mouse, pocket gopher, Black-tailed Jackrabbit, California Vole, California Ground Squirrel, Pacific Treefrog, American Bullfrog, Red-eared Slider (*Trachemys scripta*), Northwestern Fence Lizard, Northwestern Garter Snake, Gopher Snake, Common Garter Snake, California King Snake, and Western Toad.

The riparian cottonwood forests include Fremont Cottonwood, Goodding's Black Willow, California Grape, California Boxelder, California Blackberry, button bush, 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 California 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 2014a). 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 American 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 4, "Surface Water Supply and Management." CDFW owns the northernmost 33 acres of Decker Island and has been working with the 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 Northern River Otter, American Mink (*Neovison vison*), American Beaver, Coyote, mice and voles. Various species of raptors, waterfowl, songbirds, and shorebirds have also been observed. Amphibians and reptiles such as Pacific Treefrog, Northwestern Fence Lizard, and Gopher Snake have been seen. Invasive plants such as Perennial Pepperweed, Yellow Star Thistle (*Centaurea solstitialis*), Water Hyacinth, and Brazilian Waterweed (*Egeria densa*) 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 species, Red Alder, and California Wild Rose. 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 Salt Grass. 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, Western Gray Squirrel, vole species, pocket gopher, Feral Cat (*Felis silvestris* ssp.), Red Fox, and Coyote. Muskrat and American Beaver may be found in the marsh vegetation. Typical reptiles and amphibians include Northwestern Fence Lizard, snakes, frogs, and toads.

Rhode Island Wildlife Area Rhode Island Wildlife Area is a 67-acre island, located in Contra Costa County that is managed by CDFW (CDFW 2014b). 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; Great and Snowy Egret; and Mallard, Cinnamon Teal, and Wood ducks.

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 2014c). The area supports a wide variety of waterfowl, including Northern Pintail, Mallard, Northern Shoveler, and Green-winged Teal ducks; and American Wigeon. Ferruginous Hawks (*Buteo regalis*) and Rough-legged Hawks (*Buteo lagopus*) winter in the area while year-round residents such as Golden Eagle, Northern Harrier, and Red-tailed Hawk forage over the ponds and upland areas. Mammals including Raccoon, Black-tailed Jackrabbit, and vole are found here and are preyed upon by Coyote.

Grizzly Island Wildlife Area Grizzly Island Wildlife Area is administered by CDFW and consists of approximately 15,300 acres of tidal wetlands and managed marshes within Suisun Marsh (CDFW 2014d, 2014e). 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 Wigeon, Greater White-fronted Goose, Great Blue Heron, Snowy Egret, Black-crowned Night Heron, Yellowthroat, Marsh Wren, Suisun Song Sparrow, American White Pelican, Ferruginous Hawk, Sharp-shinned Hawk (*Accipiter striatus*), 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 Northern River Otter and Tule Elk.

Fremont Weir Wildlife Area The Fremont Weir Wildlife Area is located within the Yolo Bypass from the Sacramento River to downstream from 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 4, "Surface Water Supply and Management." The 1,461-acre refuge includes Valley Oak, willow, cottonwood, brush, and weedy vegetation (CDFW 2014f). The area supports Ring-Neck Pheasant, California Quail, Mourning Dove, a range of waterfowl species similar to those described for the Yolo Bypass, Brush Rabbit (*Sylvilagus bachmani*), and Black-tailed 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 4, "Surface Water Supply and Management." The 360-acre refuge includes Valley Oak, willow species, Fremont Cottonwood, and weedy vegetation (CDFW 2014g). The area supports raptors, songbirds, Ring-Neck 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 approximately 15 miles south of Dixon and is only accessed by boat through Lindsay Slough (CDFW 2014h). Vegetation in Calhoun Cut includes grasslands, marshes, and riparian vegetation (Witham and Karacfelas 1994). The grasslands include native Purple Needle Grass (*Stipa pulchra*).

Impact Analysis

This section describes the potential mechanisms and analytical methods for change in terrestrial resources; results of the impact analysis; any need for mitigation measures; and cumulative effects.

Potential Mechanisms for Change and Analytical Methods

As described in Chapter 3, "Considerations for Describing Affected Environment and Environmental Consequences," this impact analysis considers changes in terrestrial resources conditions related to or caused by augmentation of Trinity River flows from Trinity Lake and Lewiston Reservoir under Alternatives 1 and 2 as compared to the No Action Alternative.

Implementation of the action alternatives, as compared to the No Action Alternative, could affect these resources by altering the ecological attributes of plant communities or other habitat characteristics upon which terrestrial wildlife depend. Potential mechanisms of change to terrestrial resources fall into the following general causative categories associated with the alternatives:

1. Changes in habitat and species composition resulting from changes in flow releases downstream from CVP/SWP facilities.

2. Changes in habitat and species composition resulting from changes in storage levels in CVP/SWP reservoirs.

Mechanisms for change are analyzed in the following discussion. For reasons explained, some of these mechanisms are eliminated from further analysis of effects on terrestrial resources resulting from implementation of the action alternatives compared to the No Action Alternative, while other mechanisms of change are introduced for the purpose of further analysis in the following section, *Evaluation of Alternatives*.

Changes in Habitat and Species Composition Resulting from Changes in Flow Releases Downstream from CVP/SWP Facilities

Changes in Rivers Downstream from CVP and SWP Reservoirs Implementation of action alternatives would influence river flow regimes that renew and support adjacent riparian and wetland plant and wildlife communities. For example, certain riparian plants such as willow species 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. Conversely, increased discharge from Trinity Lake into the Trinity and Klamath Rivers in late August, September and October could cause flows in Clear Creek and Sacramento River to be reduced, since Trinity Lake supplies may not be available for diversion via Whiskeytown Lake or the Spring Creek diversion during those months (under Alternative 1). This could result in effects on terrestrial resources in Clear Creek and Sacramento River due to lower flows in these months, either due to decreased habitat values of riparian vegetation or due to changes in species composition from decreased food availability or reproductive success.

CalSim II modeling results (Chapter 4, “Surface Water Supply and Management”) provide information on flows below CVP and SWP reservoirs which aid in the analysis. The CalSim II modeling results can be used to provide a qualitative analysis on downstream terrestrial resources but does not include specific information on wetted stream area and therefore site specific evaluation of all terrestrial resource effects within and adjacent to these rivers and their riparian corridors is not possible. This analysis focuses on qualitative changes to these terrestrial resources and their habitats.

The analysis is focused on the Klamath, Trinity, Sacramento, Feather, and American Rivers and Clear Creek below Whiskeytown Dam because the flow regimes of these rivers may be altered by implementation of the action alternatives. Rivers downstream from other reservoirs in the CVP and SWP system are not included in this scope of analysis, either because their flows are conveyed by canal systems or pipelines with no or negligible terrestrial resource values, or because they are located south of the Delta such that changes in river flows under the action alternatives compared to the No Action Alternative are projected to be less than 1 percent in all months of all Sacramento water year types, or both.

As discussed above in *Affected Environment* of this chapter, the TRRP has established a comprehensive program to manage and restore riparian resources adjacent to the Trinity River between Lewiston Dam and the North Fork. TRRP has undertaken channel reconstruction projects to selectively remove much of the riparian encroachment that has developed since creation of Trinity Lake and Lewiston Reservoir. Riparian vegetation planted on the restored

floodplains will be managed to encourage natural riparian growth on the floodplain and limit encroachment on the newly formed gravel bars. Monitoring efforts are underway to document the success of the altered riparian corridor. Augmentation of Klamath River flows using flows from Trinity Lake storage under the action alternatives as compared to the No Action Alternative could alter the success of riparian restoration efforts and result in effects on terrestrial wildlife that inhabit and depend on the Trinity River riparian corridor. Also, alteration of *Trinity River Mainstem Fishery Restoration Final EIS/Environmental Impact Report Record of Decision* (ROD) flows in spring to provide the storage needed for fall releases, as proposed in Alternative 2, could alter the effectiveness of Trinity River riparian restoration efforts and in turn wildlife which depend on the floodplain riparian corridor. Augmentation of flows along the lower Klamath could also affect wildlife which rely on the lower Klamath River and its riparian corridor.

Foothill Yellow-legged Frog and Western Pond Turtle are both identified by CDFW as Species of Special Concern. Foothill Yellow-legged Frogs breed on the Trinity River below Lewiston Dam from early April to mid-June (Wheeler et al. 2014) while Western Pond Turtles breed in May, June and July (USFWS and Hoopa Valley Tribe 1999). Foothill Yellow-legged Frog deposit their eggs in shallow, low-velocity areas along rocky, sparsely vegetated river bars (Lind et al. 1996). Tadpoles remain in low velocity areas until they metamorphose. Western Pond Turtles dig burrows to lay their eggs above the wetted perimeter in May, June and July (USFWS and Hoopa Valley Tribe 1999). The hatchlings migrate to slow, protected backwater pools and utilize the abundant zooplankton typical of these warmer backwater habitats.

Alterations in flow regimes and river temperatures below Lewiston Dam pursuant to Alternative 2 during these species' breeding periods (April through June) might affect their breeding success. Additionally, alterations in Trinity and Klamath River temperatures in August and September under either action alternative may affect these species by reducing aquatic life-stage growth and development rates.

Changes in Floodplains and Associated Wetlands of Sacramento River and Tributaries and the Delta Augmentation of Klamath River flows using flows from Trinity Lake storage under the action alternatives as compared to the No Action Alternative could alter the movement of flood flows from the Sacramento River or from its tributaries downstream from CVP/SWP facilities into adjacent floodplains and wetlands. These higher flows can provide habitat for wildlife within floodplains and associated wetlands and typically occur during late fall, winter and early spring, during the months of December through May.

Under all alternatives, development along major river corridors in the Sacramento 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, would prevent development within the floodplains and floodways of the Delta and adjacent to the Sacramento, Feather and American Rivers and Clear Creek upstream from the Delta.

Analysis of CalSim II modeling results (Chapter 4, "Surface Water Supply and Management") indicates that action alternatives would result in up to 1 percent difference in flows compared to the No Action Alternative during any month of any Sacramento River water year type, during the months of December through May, for Sacramento River below Keswick Dam, Clear Creek below Whiskeytown Dam, American River below Nimbus Dam, Feather River below Oroville Dam, Sacramento River at Freeport, and Delta Outflow. During the months of July, several rivers may have reductions in flows under the action alternatives compared to the No Action Alternative of up to 5 percent, however, such a reduction would not change any floodplains or reduce wetland hydrology fed from floodplains. These results indicate that the action alternatives would have no effects on terrestrial resources resulting from changes in river and Delta floodplains and associated wetlands compared to the No Action Alternative, and this potential effect is not further examined in this EIS.

Changes in Flows into the Yolo Bypass The Yolo Bypass receives flow from the Sacramento River through the Fremont Weir during significant winter and spring flood flow events. Analysis of CalSim II modeling results (Chapter 4, "Surface Water Supply and Management") indicates that action alternatives would result in less than 1 percent difference compared to the No Action Alternative during any month of any Sacramento River water year type, except during January of "Dry" water year type, which shows a -1 percent change in flow into the Yolo Bypass for both Alternatives 1 and 2 compared to the No Action Alternative. These results indicate that the action alternatives would have no effects on terrestrial resources within the Yolo Bypass compared to the No Action Alternative, and this potential effect is not further examined in this EIS.

Changes in Wildlife Refuges Wildlife Refuges in the Sacramento Valley receive water from the CVP under the Refuge Water Supply and Conveyance Program, managed jointly by the USFWS and the U.S. Department of the Interior, Bureau of Reclamation (Reclamation) (USFWS 2012). The Program provides that Level 2 supplies (422 thousand acre-feet (TAF) in the aggregate for all refuges in the CVP system) be provided to all refuges for basic water supply needs for wildlife. Although portions of the Incremental Level 4 supplies (an additional 133 TAF over all refuges) have at times been available to some of the refuges, they are not considered part of the No Action Alternative as they are subject to annual determination based on availability and willing water rights sellers. The water is used to flood refuge lands to provide for annual vegetative recovery and open water habitat for waterfowl. Analysis of CalSim II modeling results (Chapter 4, "Surface Water Supply and Management") indicates that action alternatives would result in 0 percent difference in Level 2 supplies compared to the No Action Alternative during any Sacramento Water Year Type, except during "Critical" years, which shows a 1 percent reduction in Level 2 Refuge water supplies for both Alternatives 1 and 2 compared to the No Action Alternative. These results indicate that the action alternatives would have no effects on terrestrial resources within Sacramento Valley wildlife refuges compared to the No Action Alternative, and this potential effect is not further examined in this EIS.

Changes in Salinity in and Adjacent to Waterways of the Delta Augmentation of Klamath River flows using flows from Trinity Lake storage under the alternatives as compared to the No Action Alternative could change the Delta salinity which could affect survival of riparian vegetation and wildlife which depend on it. The analysis evaluates changes in salinity by comparing the end of month X2 position. The X2 position is the extrapolated distance upstream

from the Golden Gate Bridge where the salinity isohaline at 1 meter above bottom is 2 parts per thousand. Chapter 5, "Surface Water Quality," indicates that in all months of all water year types, the X2 position of the action alternatives is a 0 percent change from the No Action Alternative, and in only 5 months of all water year types, it is calculated at 0.1 kilometer less (closer to the Bay) than the No Action Alternative. These results indicate that the action alternatives would have no or negligible effects on terrestrial resources resulting from changes in Delta salinity compared to the No Action Alternative, and this potential effect is not further examined in this EIS.

Changes in Agricultural Acreage Irrigated with CVP and SWP Water Augmentation of Klamath River flows using Trinity Lake storage under the action alternatives as compared to the No Action Alternative could change the extent of irrigated acreage and associated habitats by changing water deliveries to agriculture. It should be noted that certain agricultural crops contribute substantially to wildlife habitat values, whereas other crops have substantially less or negligible value to wildlife, hence a given reduction in water deliveries to agriculture may have a less than pro rata effect on wildlife which rely on agricultural acreage as habitat. For example, as explained above in *Affected Environment* of this chapter, rice and alfalfa fields provide much higher habitat values to wildlife, particularly waterfowl, than orchard or row crops. However, rice and alfalfa and other crops with higher value as wildlife habitat account for approximately one-third of total agricultural water use in California's Central Valley, while row crops and orchards use approximately two-thirds of agricultural water (DWR 2014).

Changes in Habitat and Species Composition from Changes in Storage Levels in CVP/SWP Reservoirs

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 or enlargement of barren zones through reservoir drawdown can also affect the ability of wildlife species to gain access to water and food sources, and could cause them to be more vulnerable to predation, particularly as reservoirs are drawn down to minimum levels in the Fall.

As described in Chapter 4, "Surface Water Supply and Management," CalSim II modeling results provide information on expected elevation changes of Trinity, Whiskeytown, Shasta, and Folsom Lakes and Lake Oroville, for each month of the year of the relevant water year type.

Evaluation of Alternatives

As described in Chapter 3, "Considerations for Describing Affected Environment and Environmental Consequences," action alternatives have been compared to the No Action Alternative.

No Action Alternative

For the analysis of effects on terrestrial biological resources, the No Action Alternative is comparable to the conditions described in the *Affected Environment* portion of this chapter. The effects of climate change and sea level rise are assumed to be included in the No Action

Alternative. The effects of climate change would be the same under the action alternatives as under the No Action Alternative. Sea level rise may affect the salinity level of the Delta, but would not change the analysis of effects due to salinity of the action alternatives as compared to the No Action Alternative.

Proposed Action (Alternative 1)

Lower Klamath and Trinity River Region

Changes in Rivers Downstream from CVP and SWP Reservoirs

Trinity River CalSim II modeling results provide information on river flows of the Trinity River below Lewiston Dam under Alternative 1 compared to the No Action Alternative. Results indicate that for the months of the year when augmentation is not underway (all months of the year except August – September) average flows in most months of most Trinity water years would be within the range of 2 percent more than or less than the flows under the No Action Alternative, with the exception of 3 months in which flows under Alternative 1 are reduced by 6-8 percent. Changes in flow of this magnitude are expected to result in no or negligible positive or negative effects on terrestrial resources, as they are well within the range of seasonal and year to year anomalies in flow that wildlife species are typically equipped to adapt to. The 8 percent flow reduction in February of below normal Trinity water year type is earlier than the breeding season for most waterfowl and birds in the Trinity River region (USFWS et al. 2000). Thus this reduction would not adversely affect nesting birds.

CalSim II modeling results further show that, under Alternative 1 compared to the No Action Alternative, flows in August and September, months in which Trinity River ROD flows would be augmented under this alternative, will increase by 5 percent to 117 percent depending on the water year type. However, augmentation flows under Alternative 1 would be less than twice the No Action flow in approximately 55 percent of years in which any augmentation is needed. Augmentation years with higher releases occur most often in dry and critically dry years. In general, increased water flows in late summer and early fall would have a positive effect on riparian resources and terrestrial wildlife. As vegetation struggles to survive low water periods, particularly in dry and critically dry water years, the additional inundation could have a minor positive effect on riparian vegetation. However, as reviewed above and in the *Affected Environment* section of this chapter, goals of the TRRP include the sustained removal of vegetation which has in the past invaded the low flow channel, trapped sediments and narrowed the channel. The duration of increased flows would be no more than 2 months, which may be too short a period to result in substantial vegetation recruitment. Additionally, under Alternative 1 and the No Action Alternative, TRRP will continue to provide scouring flows in late April, May and June which can be expected to continue to prevent germination of new vegetation in the active channel by inundation and scouring of the channel. Also, Adaptive Management and Monitoring efforts by TRRP for sustaining the corrected low flow channel and revegetating upper river terraces above the low flow channel will continue under all alternatives. For these reasons, changes of flow of this magnitude are expected to have negligible effects on riparian resources and wildlife which rely on the Lower Trinity River riparian corridor.

Temperature decreases in the Trinity River downstream from Lewiston Dam and in the lower Klamath River in late summer associated with implementation of the action alternatives could affect both Foothill Yellow-legged Frog and Western Pond Turtle due to these species' reliance on water temperatures that optimize growth and food availability, particularly for young of the

year and juveniles (Ashton et al. 2015, Wheeler et al. 2014). This analysis is based on the one-dimensional daily averaged water-temperature outputs from the RBM 10 water temperature models for the Trinity and Klamath Rivers, the analytic procedures for which are described in Chapter 5 "Surface Water Quality." Under Alternative 1, when fall flows are augmented in August and September, water temperatures in the Trinity River below Lewiston Dam in critical Trinity water years will be up to -2.8 ºF and -6.6 ºF degree F less, respectively than the No Action Alternative. Although this amount of temperature reduction in August and September represents up to 9 percent change from the No Action Alternative, it may result in a temporary, minor effect on these species because of their ability to behaviorally, thermo-regulate at this life-stage.

Klamath River Flows in the lower Klamath River below its confluence with Trinity River will increase in August and September under Alternative 1 compared to the No Action Alternative. At this time of year, flows in the Klamath River above the confluence can be expected to be low, particularly in dry and critical Trinity water year types. Riparian vegetation below the confluence will be more likely to survive through the dry late summer and fall as a result, and terrestrial species will undergo less stress from restricted access to water or adequate access to water adjacent to cover. The addition of flows from Trinity River in these months under Alternative 1 would have a temporary positive effect on riparian vegetation and terrestrial resources compared to the No Action Alternative.

Changes in CVP and SWP Reservoir Elevations CalSim II modeling results provide information on expected elevation changes of Trinity Lake, for each month of the Trinity water year type for Alternative 1 compared to the No Action Alternative. Results indicate that in all months of all Trinity water year types, elevation changes would be less than 1 percent. Changes in surface elevation would be 2 feet or less on average for all months of all water years except August, September, October and November of Critical water years, when reservoir elevations would vary between 3 feet and 6 feet less than under the No Action Alternative. During these events, reservoir levels may force some species to travel further across barren shorelines to access the water, which may leave them more exposed to predation. It may also make it more difficult for some species to reach food sources.

Sacramento Valley and Bay-Delta Region

Changes in Rivers Downstream from CVP and SWP Reservoirs CalSim II modeling results provide information on monthly average river flows of the Sacramento, Feather and American Rivers and Clear Creek, below CVP and SWP dams. They indicate that in all months of the year under all Sacramento water year types, changes in flow for Alternative 1 compared to the No Action Alternative will result in flow changes of plus or minus 2 percent, except as follows: for the Sacramento River in critical water years, September flows will be 4 percent less; for Feather River in critical water years June flows will be 7 percent higher; and for American River in critical water years, July flows will be 5 percent lower and September flows will be 6 percent higher. These results indicate that changes in rivers below CVP and SWP reservoirs under Alternative 1 compared to the No Action Alternative will have similar effects on wildlife in all months of most water year types, and will have minor positive effects on wildlife on the Feather River in June of critical water years and on the American River in September of critical water years.

Changes in Agricultural Acreage Irrigated with CVP and SWP Water CalSim II modeling results provide information on deliveries to Sacramento Valley agriculture. In wet, above normal, below normal and dry Sacramento water year types, annual average agricultural water deliveries north of the Delta would range from 0 percent to 4 percent less under Alternative 1 than under the No Action Alternative. In Sacramento critical water years, annual average agricultural water deliveries north of the Delta would be 11 percent less under Alternative 1 than the No Action Alternative. A reduction of 4 percent or less in water deliveries to agriculture might slightly reduce the number of acres under irrigation which are valuable to wildlife. A reduction of 11 percent in water deliveries to agriculture in Sacramento critical water years would likely reduce agricultural acreage. As noted above in *Potential Mechanisms of Change and Analytical Methods* of this chapter, rice and alfalfa fields provide much higher habitat values to wildlife, particularly waterfowl, than orchard or row crops, but account for approximately one-third of total agricultural water use in California's Central Valley. Row crops and orchards use approximately two-thirds of agricultural water, and in many cases have very minor value as habitat for wildlife. Thus, the 11 percent reduction in annual average water deliveries in critical Sacramento water years will not have a pro rata negative effect on wildlife. Reduction of water supplies to Sacramento Valley agriculture in critical water years under Alternative 1 will have a minor adverse effect on Sacramento Valley wildlife which utilize agriculture.

Changes in CVP and SWP Reservoir Elevations CalSim II modeling results provide information on expected elevation changes of Whiskeytown, Shasta, and Folsom Lakes and Lake Oroville, for each month of the Sacramento water year type for Alternative 1 compared to the No Action Alternative. Monthly average water surface elevations in all these reservoirs under Alternative 1 are similar to under the No Action Alternative with changes of 0 percent in almost all months of all water year types, and -1 percent in only several months. The changes are in all cases less than or equal to 1 foot in elevation. Changes in reservoir elevations of this magnitude would not be expected to alter success of wildlife in obtaining access to food sources, successfully breeding, or evading predators, thus changes in CVP and SWP reservoir elevations under Alternative 1 would have no or negligible effects on terrestrial wildlife resources at these reservoirs.

Trinity River ROD Flow Rescheduling Alternative (Alternative 2)

Lower Klamath and Trinity River Region

Changes in Rivers Downstream from CVP and SWP Reservoirs

Trinity River CalSim II modeling results provide information on monthly average river flows of the Trinity River below Lewiston Dam under Alternative 2 compared to the No Action Alternative. Results indicate that for the months of the year when augmentation is not underway (all months of the year except August – September) average flows in most months of most Trinity water years would be in the range between 5 percent more or 5 percent less than flows under the No Action Alternative. Changes in flow of this magnitude are expected to result in no or negligible positive or negative effects on terrestrial resources, as they are well within the range of seasonal and year to year anomalies in flow that wildlife species are typically equipped to adapt to. Flows in May and June of dry water years would be reduced by 7 percent and 8 percent respectively compared to the No Action Alternative, and flows in May and June of critical water years would be reduced by 14 percent and 29 percent respectively compared to No Action Alternative. These data reveal the key feature of Alternative 2, which is designed to provide additional storage in Trinity Lake for potential flow augmentation in those years when the need

is anticipated, by adjusting the timing of delivery of scouring and pulse flows as provided by the Trinity River ROD. Analysis of Trinity River ROD flow curve adjustments to accommodate the reserved storage under Alternative 2 shows that compared to the No Action Alternative the reduction of 7 to 8 percent in May and June of Trinity dry water years would occur over a time span of several days (Reclamation 2016). Based on this, the reduction in flows in May and June of Trinity dry water years would be a negligible adverse effect on terrestrial resources as it might slightly limit efforts to control riparian encroachment into the channel by the TRRP at the expense of preferred riparian growth on the upper terrace.

In dry and critically dry water years, scheduled Trinity River ROD flows in May and June are not high enough to provide a significant degree of scour to the low flow channel. However, the Trinity River ROD flows in theses months in dry and critical years serve to discourage germination of riparian plants on lower bar surfaces and minimally recharge groundwater. As the spring Trinity River ROD flow is reduced, the rate of flow reduction is intended to result in a reduction in river stage of less than or equal to 0.1 feet per day.

Under Alternative 2, the flow recession rates in all water year types would be similar to the No Action Alternative. The stage reduction will be less than 0.1 feet per day, thus there would be no effect on riparian resources due to the rate of flow reduction. However, the reduced duration of peak Trinity River ROD flows in critically dry years would reduce the period in which the terrace and floodplain above the low flow channel would be inundated, and thus may have a minor adverse effect on recruitment of riparian vegetation above the low flow channel.

CalSim II modeling results show that under Alternative 2 compared to the No Action Alternative, average flows in August and September will increase by 5 percent to 129 percent depending on the water year type. However, augmentation flows under Alternative 2 would be less than twice the No Action flow in approximately 55 percent of years in which any augmentation is needed. Years in which augmentation to prevent disease outbreak in the lower Klamath River is necessary occur most often in dry and critically dry years. In general, increased water flows in late summer and early fall would have a positive effect on riparian resources and terrestrial wildlife. As vegetation struggles to survive low water periods, particularly in Trinity dry and critical water years, the additional inundation could have a minor positive effect on riparian vegetation. However, as reviewed above and in the *Affected Environment* section of this chapter, goals of the TRRP include the sustained removal of vegetation which has in the past invaded the low flow channel, trapped sediments and narrowed the channel. The duration of increased flows would be no more than 2 months, which occurs outside of the germination window and may be too short a period to result in substantial vegetation recruitment. Additionally, under Alternative 2 compared to the No Action Alternative, TRRP will continue to provide pulse flows in late April, May and June which can be expected to continue to prevent germination of new vegetation in the active channel by inundation and scouring of the channel. Also, Adaptive Management and Monitoring efforts by TRRP for sustaining the corrected low flow channel and revegetating upper river terraces above the low flow channel will continue under all alternatives. For these reasons, changes of flow of this magnitude are expected to have negligible effects on riparian resources and wildlife which rely on the Trinity River riparian corridor below Lewiston Dam.

In critically dry Trinity water years under Alternative 2, Trinity River ROD flows in late May and early June will be reduced to the summer minimum of 450 cubic feet per second (cfs) (at Lewiston Dam) approximately 2 weeks sooner than the No Action Alternative or Alternative 1. As noted above, the rate of flow reduction of the spring Trinity River ROD flow (the "descending curve") under Alternative 2 is designed to result in a river stage reduction of less than 0.1 feet per day, consistent with Trinity River Flow Evaluation Report (USFWS and Hoopa Valley Tribe 1999). This rate of reduction has been determined in part to minimize adverse effects on Foothill Yellow-legged Frog which are depositing eggs in floodplain and river bar pools along the river margin during April, May and June. Although the Trinity River ROD flow under Alternative 2 in critically dry water years will be reduced to the 450 cfs base flow approximately two weeks earlier than under the No Action Alternative, effects on Foothill Yellow-legged Frogs are expected to be similar to the No Action Alternative because river stage reduction rates will not be changed.

Under Alternative 2, primarily in critically dry years, warmer temperatures in the Trinity River mainstem resulting from earlier cessation of spring Trinity River ROD flows may improve Foothill Yellow-legged Frog breeding success, tadpole development, and may advance the breeding season for this species (Wheeler et al. 2014). An earlier reduction in spring Trinity River ROD flows pursuant to Alternative 2, combined with a corresponding greater influence in temperature elevation from tributaries, might have a slight positive effect on Foothill Yellow-legged Frog breeding success and tadpole development.

Western Pond Turtles deposit eggs in burrows above the river's wetted perimeter, typically in May, June and July. Under Alternative 2 in critically dry water years, an earlier reduction of the Trinity River ROD flows (approximately two weeks) would not have an effect on their breeding success. An earlier reduction in spring Trinity River ROD flows in critically dry water years, under Alternative 2, combined with a corresponding greater influence in temperature from the warmer tributaries, might have a slight positive effect on Western Pond Turtle young-of-the-year and juveniles, which may be seeking out warmer refugia and food supplies during this period (Ashton et al. 2015).

Klamath River Flows in the lower Klamath River below its confluence with Trinity River will increase in August and September under Alternative 2 compared to the No Action Alternative. At this time of year, flows in the Klamath River will be low, particularly in Trinity dry and critical water year types. Riparian vegetation will be more likely to survive through late summer and fall when riverside conditions are dry as a result, and terrestrial species will undergo less stress and predation from restricted access to water or cover. The addition of flows from Trinity River in these months under Alternative 2 would have a temporary positive effect on riparian vegetation and terrestrial resources compared to the No Action Alternative. Depending on water year type under Alternative 2, Trinity River ROD flows in late May and early June will be reduced to the summer minimum of 450 cfs (at Lewiston Dam) approximately one day to 14 days sooner than they would under the No Action Alternative that could negatively affect riparian habitat in the lower Klamath River. However, on the lower Klamath River during these periods, the reduction in flow would have a diminished effect due to combined flows from the Klamath River and Trinity basin tributaries.

Changes in CVP and SWP Reservoir Elevations CalSim II modeling results provide information on expected elevation changes of Trinity Lake, for each month of the Trinity water year type for Alternative 2 compared to the No Action Alternative. Results indicate that in all months of all Trinity water year type, elevation changes would be less than 1 percent. Changes in average surface elevation would be 2 feet or less for all months of all water years except June, July and September of critical water years, when reservoir elevations would be from 3 feet to 4 feet less than the No Action Alternative. During these events, reservoir levels would not adversely affect most species' breeding success, but may force some species to travel further across barren shorelines to access the water, which may leave them more exposed to predation. It may also make it more difficult for some species to reach food sources. This represents a very minor impact to terrestrial wildlife species under Alternative 2.

Sacramento Valley and Bay-Delta Region

Changes in Rivers Downstream from CVP and SWP Reservoirs CalSim II modeling results provide information on river flows of the Sacramento, Feather and American Rivers and Clear Creek, below CVP/SWP dams. They indicate that in all months of the year under all Sacramento water year types, changes in average flow for Alternative 2 compared to the No Action Alternative will be plus or minus 2 percent, except as follows: for the Sacramento River in critical water years, average September flows will be 3 percent less; for Feather River in critical water years average June flows will be 7 percent higher; and for American River in critical water years, average September flows will be 5 percent higher. These results indicate that changes in rivers below CVP and SWP reservoirs will have no or negligible positive or negative effects on wildlife in all months of nearly all water year types, and will have minor positive effects on wildlife on the Feather River in June of critical water years.

Changes in Agricultural Acreage Irrigated with CVP and SWP Water CalSim II modeling results provide information on deliveries to Sacramento Valley and Delta agriculture. In wet, above normal, below normal and dry Sacramento water year types, average annual agricultural water deliveries in and north of the Delta would be less than 1 percent less under Alternative 2 than under the No Action Alternative. In Sacramento critical water years, average annual agricultural water deliveries in and north of the Delta would be 1 percent less under Alternative 2 than the No Action Alternative. Thus, in all Sacramento water year types, agricultural water deliveries in the Sacramento Valley under Alternative 2 will be reduced by 1 percent or less compared to the No Action Alternative, and changes in Sacramento Valley irrigated agricultural acreage under Alternative 2 will have no effects on terrestrial wildlife.

Changes in CVP and SWP Reservoir Elevations CalSim II modeling results provide information on expected elevation changes of Whiskeytown, Shasta, and Folsom Lakes and Lake Oroville, for each month of the Sacramento water year type for Alternative 2 compared to the No Action Alternative. Average water surface elevations in all these reservoirs under Alternative 2 are similar to under the No Action Alternative with changes of less than 1 percent in all months of all water year types. The changes are in all cases less than or equal to 1 foot in elevation. Changes in reservoir elevation of this magnitude would not be expected to alter success of wildlife in obtaining access to food sources, or to evade predators, thus changes in CVP and SWP reservoir elevations under Alternative 2 would have no or negligible effects on terrestrial wildlife resources at these reservoirs.

Summary of Environmental Consequences

The results of the environmental consequences of implementation of action alternatives as compared to the No Action Alternative are presented in Table 8-2.

Table 8-2. Comparison of Action Alternatives to No Action Alternative

Alternative	Potential Change	Consideration for Mitigation Measures
Alternative 1	Terrestrial resources at Trinity Lake and on the Trinity River would be similar to the No Action Alternative for most months and year types, except for: • Minor adverse effects on terrestrial wildlife species at Trinity Lake in September of critically dry water years due to decreased storage elevation. • Minor effects to Yellow-legged Frog and Western Pond Turtle from changes in flow and water temperature in Trinity River in late summer. • Temporary minor positive effects on riparian terrestrial habitat and terrestrial wildlife on the Trinity River in August and September due to increased flows. Terrestrial resources on the lower Klamath River would be similar to the No Action Alternative for most months and year types except for minor positive effects on riparian terrestrial habitat and terrestrial wildlife in August and September due to increased flows. Minor positive effects on terrestrial resources on the Feather River in June of critical water years and on the American River in September of critical water years. Alternative 1 would reduce habitat for Sacramento Valley wildlife which utilize agricultural lands due to reduced water supplies in critical water years.	None Needed
Alternative 2	Terrestrial resources at Trinity Lake and on the Trinity River would be similar to the No Action Alternative for most months and year types, except for: • Minor positive effects on terrestrial wildlife species at Trinity Lake during June through August of critical water years due to increased storage elevation and minor adverse effects in September in these years due to decreased storage elevation. • Minor adverse effect on terrestrial resources on Trinity River in May and June of critically dry water years due to flow reductions which may hinder TRRP efforts to control riparian vegetation. • Minor positive effect on Foothill Yellow-legged Frog breeding success and tadpole development, and Western Pond Turtles young-of-the-year and juveniles resulting from increased water temperatures in critically dry years. • Minor effects to Yellow-legged Frog and Western Pond Turtle from changes in flow and water temperature in Trinity River in August and September. Terrestrial resources on the lower Klamath River would be similar to the No Action Alternative for most months and year types, except for: • Minor adverse effect on terrestrial resources in late May and early June of critically dry water years due to reduction of Trinity River ROD flows. • Temporary positive effects on riparian terrestrial habitat and terrestrial wildlife in the August and September due to increased flows. Minor positive effects on terrestrial resources on the Feather River in June of critical water years and on the American River in September of critical water years.	None needed

Potential Mitigation Measures

Mitigation measures are included in EIS to avoid, minimize, rectify, reduce, eliminate, or compensate for adverse environmental effects of alternatives as compared to the No Action Alternative. Implementation of Alternatives 1 or 2 as compared to the No Action Alternative would result in very minor to minor adverse changes in terrestrial resources along the Trinity and Klamath Rivers and at Trinity Lake at certain times of the year and under certain water year types. Implementation of Alternative 1 as compared to the No Action Alternative would have minor adverse effects on Sacramento Valley wildlife which utilize agriculture due to reduced water supplies in critical water years. Because these adverse effects are very minor or minor in degree, no mitigation measures have been identified.

Cumulative Effects Analysis

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 terrestrial resources is summarized in Table 8-3. The methodology for this cumulative effects analysis is described in the Cumulative Effects Technical Appendix.

Table 8-3. Summary of Cumulative Effects on Terrestrial Resources of Action Alternatives as Compared to the No Action Alternative

Scenarios	Cumulative Effects of Actions
No Action Alternative with Associated Cumulative Effects Actions in Year 2030	*Conditions and actions included in Quantitative Analyses* *(Conditions and actions incorporated into No Action modeling)* 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 or habitat are anticipated to improve shoreline, riparian, and floodplain habitat. *Additional Identified Actions* *(Additional projects identified in Cumulative Effects Technical Appendix)* Some of the future reasonably foreseeable actions, including Hoopa Valley Tribe watershed restoration projects and FERC relicensing projects, would improve shoreline, riparian, and floodplain habitat. Additional reasonably foreseeable actions under this cumulative effects analysis are not anticipated to change CVP water deliveries or associated habitat for Central Valley wildlife which utilize irrigated agricultural lands.
Alternative 1 with Associated Cumulative Effects Actions in Year 2030	*Alternative 1 with Conditions and actions included in Quantitative Analyses* Implementation of Alternative 1 would result in similar terrestrial resources conditions (shoreline, riparian, and floodplain habitat) as under the No Action Alternative. *Alternative 1 with Additional Identified Actions* The additional reasonably foreseeable actions would result in beneficial effects to terrestrial habitats in the Trinity River Subbasin, and therefore cumulative effects to terrestrial resources conditions are not anticipated.
Alternative 2 with Associated Cumulative Effects Actions in Year 2030	*Alternative 2 with Conditions and actions included in Quantitative Analyses* Implementation of Alternative 2 would result in similar terrestrial resources conditions (shoreline, riparian, and floodplain habitat) as under the No Action Alternative. *Alternative 2 with Additional Identified Actions* The additional reasonably foreseeable actions would result in beneficial effects to terrestrial habitats in the Trinity River Subbasin, and therefore cumulative effects to terrestrial resources conditions are not anticipated.

Key:
CVP = Central Valley Project
FERC = Federal Energy Regulatory Commission

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Chapter 9
Hydropower Generation

Introduction

This chapter describes hydropower generation 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 hydropower generation resources through operational changes of the Central Valley Project (CVP) and State Water Project (SWP).

Affected Environment

This section describes CVP and SWP energy resources that could potentially be affected by the implementation of the alternatives considered in this EIS. These resources include CVP and SWP hydroelectric generation facilities at the CVP and SWP reservoirs; transmission of the generated electricity; and the CVP and SWP pumping facilities needed to convey water supplies to CVP and SWP water contractors.

Central Valley Project and State Water Project Electric Generation

Hydroelectric generation facilities (e.g., powerplants) are located at most of the CVP dams (see Figure 9-1). As water is released from the CVP reservoirs, the generation facilities produce power that is used by the CVP pumping plants. The SWP also generates hydroelectricity at the Oroville facilities and along the California Aqueduct at energy-recovery plants (DWR 2013a, 2013b).

Hydropower is an important source of renewable energy, and supplies between 11 and 28 percent of California's electricity, depending upon the water-year type (HWG 2014). Between 1982 and 2012, approximately 33,927 gigawatt-hours (GWh) were generated annually, on average, in California by hydropower, including approximately 4,810 GWh on average generated by the CVP (HWG 2014). Power generated by the CVP is transmitted by Western Area Power Administration (Western) to CVP facilities. Power that exceeds CVP needs is marketed by Western to electric utilities, government and public installations, and commercial "preference" customers who have 20-year contracts (Reclamation 2013). Power generated by the SWP is transmitted by Pacific Gas and 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 utility companies and members of the Western Systems Power Pool.

Figure 9-1. Central Valley Project and State Water Project Powerplants

CVP Hydroelectric Generation Facilities

The CVP power facilities include 11 hydroelectric powerplants, and have a total maximum-generating capacity of 2,053 megawatts (MW), as presented in Table 9-1. Hydrology can vary significantly from year to year, which then affects the hydropower production. Typically, in an average water year, approximately 4,500 GWh of energy is produced by CVP power facilities (Reclamation 2013). 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 9-1. Central Valley Project Hydroelectric Powerplants

CVP Facility	Capacity (Megawatts)
Trinity Powerplant	140
Lewiston Powerplant	0.3
Judge Francis Powerplant	154.4
Shasta Powerplant	714
Spring Creek Powerplant	180
Keswick Powerplant	117
Folsom Powerplant	207
Nimbus Powerplant	13.5
New Melones Powerplant	300
O'Neill Pump-Generating Plant	25.2
San Luis Powerplant (CVP portion of the William R. Gianelli/San Luis Pump-Generating Plant)	202

Sources: CEC 2016, Reclamation 2016k
Key:
CVP = Central Valley Project

Trinity River Division Powerplants The Trinity Powerplant is located along the Trinity River (Reclamation 2016a). Primary releases from Trinity Dam are made through the powerplant, and 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 2016b). It is operated in conjunction with 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 4, "Surface Water Supply and Management." 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 2016c). It generates power from water exported from the Trinity River Basin. Similar to the Trinity Powerplant, Trinity County has first preference to the power benefit from this facility.

Under the Trinity River Division Central Valley Project Act of 1955 (Public Law 84-386), 25 percent of the energy resulting from power generated by the Trinity River Division (TRD) must first be offered to preference power customers in Trinity County.

Sacramento River Powerplants The Shasta Powerplant is a peaking powerplant located downstream from Shasta Dam along the Sacramento River (Reclamation 2013, 2016d). Until the 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 2016e). Water discharged via the Judge Francis Carr Powerplant flows into 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, located at Keswick Dam along the Sacramento River downstream from Shasta Dam, regulates the flows into the Sacramento River from both Shasta Lake and Spring Creek, and can be considered a run-of-the-river powerplant (Reclamation 2016f).

American River Powerplants The Folsom Powerplant is a peaking powerplant located at Folsom Dam along the American River (Reclamation 2016g). 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 provides voltage support for the Sacramento region during summer heavy-load times.

The Nimbus Powerplant is located at Nimbus Dam along the American River, downstream from Folsom Dam (Reclamation 2016h). The Nimbus Powerplant regulates releases from Folsom Dam into the American River and can be considered as a run-of-the river powerplant.

Stanislaus River Powerplant The New Melones Powerplant is a peaking powerplant located along the Stanislaus River (Reclamation 2016i). 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.

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 2016j). 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.

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 2016k). 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 MW, with CVP's share of the total capacity being 202 MW. This facility is operated and maintained by the State of California under an operation and maintenance agreement with U.S. Department of the Interior, Bureau of Reclamation (Reclamation).

SWP Electric Generation Facilities

The SWP power facilities are operated primarily to provide power for SWP facilities (DWR 2015b). The SWP power facilities and capacities are summarized in Table 9-2. 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 9-2. State Water Project Hydroelectric Powerplants

SWP Facility	Capacity (Megawatts)
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 2015b
Key:
SWP = State Water Project

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 from 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 GWh of energy in a median-water year, while the 3 MW generated by Thermalito Diversion Dam Powerplant adds another 24 GWh per year (DWR 2015b).

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 from 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 2016k). Electricity is generated when water is transferred from San Luis Reservoir back to O'Neill Forebay for continued conveyance in the California Aqueduct. The facility 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 MW, with SWP's share of the total capacity being 222 MW. This facility is operated and maintained by the State of California under an operation and maintenance agreement with Reclamation.

East Branch and West Branch Powerplants Downstream from 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 for distribution to parts of coastal southern California. The generation rates vary at these powerplants depending upon the amount of water conveyed.

Other Energy Resources for the State Water Project Other energy supplies have been obtained by California Department of Water Resources (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 2015b). The power is available to DWR at the Sylmar Substation.

DWR has a long-term purchase agreement with the Kings River Conservation District for approximately 400 million kilowatt-hours of energy from the 165-megawatt hydroelectric Pine Flat Powerplant (DWR 2015b). DWR also purchases energy from five hydroelectric plants with 30 MW of installed capacity that are owned and operated by Metropolitan Water District of Southern California (DWR 2015b).

DWR also purchases energy under short-term purchase agreements from utilities and energy marketers of the Western Systems Power Pool (DWR 2015b). In addition, the 1988 Coordination Agreement between DWR and Metropolitan Water District of Southern Californian enables DWR to purchase and exchange energy with that entity (DWR 2015b).

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 contractors.

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 Sacramento-San Joaquin River Delta (Delta), at San Luis Reservoir, and along the Delta-

Mendota Canal and San Luis Canal portion of the California Aqueduct. Table 9-3 presents historical average-annual CVP hydropower generation and use. Monthly power generation patterns follow seasonal reservoir releases, with peaks during the irrigation season.

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. This was due to 2007 decreases in reverse flows in Old and Middle River, in accordance with legal decisions and subsequently through implementation of the Biological Opinions (BOs) issued by the U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) in 2008 and 2009, respectively, for the operation of the CVP and SWP.

Table 9-3. Hydropower Generation and Energy Use by the CVP

Calendar Year	Water Year Type[1]	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

Source: Reclamation 2015

Note:

[1] Water Year Type based on Sacramento Valley 40-30-30 Index, as described in Chapter 4, "Surface Water Supply and Management"

Key:
AN = Above Normal
BN = Below Normal
C = Critically Dry
CVP = Central Valley Project
D = Dry
W = Wet

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 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 from San Luis Reservoir ranged from 0.292 megawatt-hours (MWh)/acre-foot for users along the Delta-Mendota Canal; to 0.428 MWh/acre-foot for users along the San Luis Canal/California Aqueduct; to 0.870 MWh/acre-foot in San Benito and Santa Clara Counties.

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 9-4 presents historical average-annual SWP hydropower generation and use. Monthly power generation patterns follow seasonal reservoir releases, with peaks during the irrigation season. 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 BOs for the CVP and SWP by USFWS and NMFS in 2008 and 2009, respectively.

Table 9-4. Hydropower Generation and Energy Use by the SWP

Calendar Year	Water Year Type[1]	SWP Hydropower Generation (Gigawatt-hour)	Energy Acquired through Long-term Agreements and Purchases (Gigawatt-hour)	Energy Used by SWP Facilities (Gigwatt-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	3,650	3,970	6,089
2010	BN	3,920	5,081	7,187
2011	W	4,846	4,895	8,549
2012	BN	4,198	3,741	7,407
2013	D	3,069	3,604	5,736

Sources: DWR 2002, 2004a, 2004b, 2005, 2006, 2007, 2008, 2012a, 2012b, 2013a, 2013b, 2014, 2015a, 2015b

Note:

[1] Water Year Type based on Sacramento Valley 40-30-30 Index, as described in Chapter 4, "Surface Water Supply and Management"

Key:
AN = Above Normal
BN = Below Normal
C = Critically Dry
CVP = Central Valley Project
D = Dry
W = Wet

Energy Demands for Groundwater Pumping

Groundwater provided approximately 37 percent, on average, of the State's agricultural, municipal, and industrial water supply between 1998 and 2010—or approximately 16 million acre-feet (MAF) per year of groundwater (DWR 2013c). The use of groundwater varies throughout the State, providing anywhere from less than 10 percent for some regions, to more than 90 percent for others (DWR 2013c).

The amount of energy used statewide to pump groundwater is not well quantified (CPUC 2010). The CPUC 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 Area 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 MAF, or 36 percent of total agricultural, municipal, and industrial water supplies (DWR 2013c). The CPUC 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.

Impact Analysis

Potential Mechanisms for Change in Hydropower Generation and Analytical Methods

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.

Changes in Energy Resources Related to CVP and SWP Water Users

Energy generation is limited on a monthly basis 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, and south of, the Delta. Energy use would change with changes in CVP and SWP deliveries.

Output for reservoir elevations and flow patterns through pumping facilities from the CalSim II model (see Chapter 4, “Surface Water Supply and Management”) are used with LTGen and SWP Power Tools—as described in the Analytical Tools Technical Appendix—to estimate changes in energy generation and use. These tools estimate average annual peaking power capacity, energy use, energy generation, and net generation at CVP and SWP facilities. 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 non-SWP electricity users.

When CVP and SWP water deliveries change, it is anticipated that water users would change their use of groundwater, recycled water, and desalinated water, as described in Chapter 4, “Surface Water Supply and Management,” Chapter 6, “Groundwater Resources/Groundwater Quality,” Chapter 11, “Agricultural Resources,” and Chapter 12, “Socioeconomics.” Specific responses by water users to changes in CVP and SWP water deliveries are not known; 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 or 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).

Evaluation of Alternatives

The impact analysis in this EIS is based upon the comparison of the alternatives to the No Action Alternative projected for the year 2030.

No Action Alternative

Changes in Energy Resources Related to CVP and SWP Water Uses Under the No Action Alternative, energy resources would be comparable to the conditions described in the *Affected Environment* section of this chapter. Conditions in 2030 would be different than existing conditions primarily due to climate change and sea level rise, general plan development throughout California, and implementation of reasonable and foreseeable water resource 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. By 2030, the reservoirs would be full more frequently by the end of April or May, compared to 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 non-SWP reservoirs. Climate change would result in a decline of the long-term average CVP and SWP water supply deliveries, reducing energy requirements for conveyance of water supplies to CVP and SWP contractors.

Proposed Action (Alternative 1)

Changes in Energy Resources Related to CVP and SWP Water Use Changes in reservoir operations under Alternative 1 as compared to the No Action Alternative would result in small changes to CVP and SWP reservoir storages, as described in Chapter 4, “Surface Water Supply and Management.” These changes would result in similar CVP and SWP energy generation (less than 1 percent change) as summarized in Table 9-5. Changes in reservoir operations under Alternative 1 as compared to the No Action Alternative would result in changes to CVP and SWP deliveries; the resulting annual CVP and SWP energy use would be similar to the No Action (less than 1 percent change), as summarized in Table 9-6. CVP and SWP net generation over the long-term conditions would be similar under Alternative 1 as compared to the No Action Alternative (less than 1 percent change), as summarized in Table 9-7.

Table 9-5. Long-Term Average Energy Generation Under Alternative 1 Compared to the No Action Alternative

Year Type	Alternative 1 (GWh)	No Action (GWh)	Alternative 1 Compared to No Action (GWh)	Alternative 1 Compared to No Action (%)
CVP Facilities				
Wet	6108.6	6126.3	-17.7	-0.3%
Above Normal	4985.0	4989.4	-4.3	-0.1%
Below Normal	4211.6	4214.4	-2.8	-0.1%
Dry	3641.8	3660.4	-18.5	-0.5%
Critical	2707.7	2734.5	-26.8	-1.0%
All Years	4576.7	4591.8	-15.1	-0.3%
SWP Facilities				
Wet	6039.0	6036.4	2.7	0.0%
Above Normal	4605.3	4605.4	-0.1	0.0%
Below Normal	3997.2	3994.7	2.5	0.1%
Dry	3165.9	3164.5	1.4	0.0%
Critical	2005.4	1996.8	8.6	0.4%
All Years	4246.8	4244.0	2.8	0.1%

Key:
% = percent
CVP = Central Valley Project
GWh = gigawatt-hour
SWP = State Water Project

Table 9-6. Long-Term Average Energy Use Under Alternative 1 Compared to the No Action Alternative

Year Type	Alternative 1 (GWh)	No Action (GWh)	Alternative 1 Compared to No Action (GWh)	Alternative 1 Compared to No Action (%)
CVP Facilities				
Wet	1385.3	1386.7	-1.5	-0.1%
Above Normal	1147.9	1149.0	-1.1	-0.1%
Below Normal	1126.3	1133.8	-7.4	-0.7%
Dry	982.3	991.6	-9.2	-0.9%
Critical	685.5	692.7	-7.1	-1.0%
All Years	1112.2	1117.2	-4.9	-0.4%
SWP Facilities				
Wet	10122.5	10114.9	7.6	0.1%
Above Normal	8588.2	8586.4	1.8	0.0%
Below Normal	8202.9	8204.1	-1.2	0.0%
Dry	6595.3	6592.4	2.9	0.0%
Critical	4077.9	4058.7	19.2	0.5%
All Years	7876.9	7870.8	6.0	0.1%

Key:
% = percent
CVP = Central Valley Project
GWh = gigawatt-hour
SWP = State Water Project

Table 9-7. Long-Term Average Net Generation Under Alternative 1 Compared to the No Action Alternative

Year Type	Alternative 1 (GWh)	No Action (GWh)	Alternative 1 Compared to No Action (GWh)	Alternative 1 Compared to No Action (%)
CVP Facilities				
Wet	4723.4	4739.6	-16.2	-0.3%
Above Normal	3837.1	3840.3	-3.2	-0.1%
Below Normal	3085.3	3080.6	4.7	0.2%
Dry	2659.5	2668.8	-9.3	-0.3%
Critical	2022.2	2041.8	-19.6	-1.0%
All Years	3464.4	3474.6	-10.2	-0.3%
SWP Facilities				
Wet	-4083.5	-4078.6	-4.9	-0.1%
Above Normal	-3982.9	-3981.1	-1.8	0.0%
Below Normal	-4205.7	-4209.4	3.7	0.1%
Dry	-3429.4	-3427.9	-1.4	0.0%
Critical	-2072.5	-2061.9	-10.6	-0.5%
All Years	-3630.1	-3626.8	-3.3	-0.1%

Key:
% = percent
CVP = Central Valley Project
GWh = gigawatt-hour
SWP = State Water Project

Trinity County has first preference to TRD generated energy. TRD energy generation would be similar for Alternative 1 compared to the No Action Alternative, as summarized in Table 9-8, with most year types and the long-term average changing less than 2 percent, with the exception of a reduction of 2.5 percent in critical years.

Table 9-8. Long-Term Average Trinity River Division Energy Generation Under Alternative 1 Compared to the No Action Alternative

Year Type	Alternative 1 (GWh)	No Action (GWh)	Alternative 1 Compared to No Action (GWh)	Alternative 1 Compared to No Action (%)
Wet	811.0	820.2	-9.2	-1.1%
Above Normal	677.2	680.7	-3.5	-0.5%
Below Normal	720.9	719.3	1.6	0.2%
Dry	598.4	608.0	-9.6	-1.6%
Critical	384.4	394.37	-9.8	-2.5%
All Years	663.4	670.5	-7.0	-1.0%

Key:
% = percent
GWh = gigawatt-hour

Trinity River Record of Decision Flow Rescheduling Alternative (Alternative 2)

Changes in Energy Resources Related to CVP and SWP Water Uses Changes in reservoir operations under Alternative 2 as compared to the No Action Alternative would result in small changes to CVP and SWP reservoir storages, as described in Chapter 4, "Surface Water Supply and Management." These changes would result in similar (less than 1 percent change) CVP and

SWP energy generation as summarized in Table 9-9. Changes in reservoir operations under Alternative 2 as compared to the No Action Alternative would result in similar CVP and SWP deliveries; the resulting annual CVP and SWP energy use would be similar to the No Action Alternative (less than 1 percent change), as summarized in Table 9-10. CVP and SWP net generation over the long-term conditions would be similar under Alternative 2 as compared to the No Action Alternative (less than 1 percent change), as summarized in Table 9-11.

Table 9-9. Long-Term Average Energy Generation Under Alternative 2 Compared to the No Action Alternative

Year Type	Alternative 2 (GWh)	No Action (GWh)	Alternative 2 Compared to No Action (GWh)	Alternative 2 Compared to No Action (%)
CVP Facilities				
Wet	6116.6	6126.3	-9.7	-0.2%
Above Normal	4997.2	4989.4	7.8	0.2%
Below Normal	4227.4	4214.4	13.0	0.3%
Dry	3659.6	3660.4	-0.8	0.0%
Critical	2731.1	2734.5	-3.3	-0.1%
All Years	4591.0	4591.8	-0.8	0.0%
SWP Facilities				
Wet	6039.3	6036.4	3.0	0.0%
Above Normal	4603.2	4605.4	-2.1	0.0%
Below Normal	3995.8	3994.7	1.1	0.0%
Dry	3161.9	3164.5	-2.6	-0.1%
Critical	1998.4	1996.8	1.6	0.1%
All Years	4244.3	4244.0	0.3	0.0%

Key:
% = percent
CVP = Central Valley Project
GWh = gigawatt-hour
SWP = State Water Project

Table 9-10. Long-Term Average Energy Use Under Alternative 2 Compared to the No Action Alternative

Year Type	Alternative 2 (GWh)	No Action (GWh)	Alternative 2 Compared to No Action (GWh)	Alternative 2 Compared to No Action (%)
CVP Facilities				
Wet	1386.8	1386.7	0.1	0.0%
Above Normal	1151.5	1149.0	2.4	0.2%
Below Normal	1133.8	1133.8	0.0	0.0%
Dry	994.0	991.6	2.4	0.2%
Critical	691.7	692.7	-1.0	-0.1%
All Years	1118.0	1117.2	0.8	0.1%
SWP Facilities				
Wet	10122.0	10114.9	7.1	0.1%
Above Normal	8584.7	8586.4	-1.7	0.0%
Below Normal	8201.9	8204.1	-2.2	0.0%
Dry	6594.0	6592.4	1.6	0.0%
Critical	4061.2	4058.7	2.4	0.1%
All Years	7873.3	7870.8	2.4	0.0%

Key:
% = percent
CVP = Central Valley Project
GWh = gigawatt-hour
SWP = State Water Project

Table 9-11. Long-Term Average Net Generation Under Alternative 2 Compared to the No Action Alternative

Year Type	Alternative 2 (GWh)	No Action (GWh)	Alternative 2 Compared to No Action (GWh)	Alternative 2 Compared to No Action (%)
CVP Facilities				
Wet	4729.8	4739.6	-9.8	-0.2%
Above Normal	3845.7	3840.3	5.4	0.1%
Below Normal	3093.6	3080.6	13.0	0.4%
Dry	2665.7	2668.8	-3.1	-0.1%
Critical	2039.5	2041.8	-2.4	-0.1%
All Years	3473.0	3474.6	-1.6	0.0%
SWP Facilities				
Wet	-4082.7	-4078.6	-4.1	0.1%
Above Normal	-3981.5	-3981.1	-0.4	0.0%
Below Normal	-4206.1	-4209.4	3.3	-0.1%
Dry	-3432.2	-3427.9	-4.2	0.1%
Critical	-2062.8	-2061.9	-0.9	0.0%
All Years	-3628.9	-3626.8	-2.1	0.1%

Key:
% = percent
CVP = Central Valley Project
GWh = gigawatt-hour
SWP = State Water Project

Trinity County has first preference to TRD generated energy. TRD energy generation would be similar for Alternative 2 compared to the No Action Alternative, as summarized in Table 9-12.

Table 9-12. Long-Term Average Trinity River Division Energy Generation Under Alternative 2 Compared to the No Action Alternative

Year Type	Alternative 2 (GWh)	No Action (GWh)	Alternative 2 Compared to No Action (GWh)	Alternative 2 Compared to No Action (%)
Wet	815.0	820.2	-5.2	-0.6%
Above Normal	685.2	680.7	4.5	0.7%
Below Normal	729.1	719.3	9.8	1.4%
Dry	606.1	608.0	-1.9	-0.3%
Critical	396.7	394.3	2.5	0.6%
All Years	670.8	670.5	0.3	0.0%

Key:
% = percent
GWh = gigawatt-hour

Summary of Impact Analysis

Table 9-13 presents the results of the environmental consequences analysis for implementing the action alternatives compared to the No Action Alternative.

Table 9-13. Comparison of Action Alternatives to No Action Alternative

Alternative	Potential Change	Consideration for Mitigation Measures
Alternative 1	CVP and SWP annual energy generation, energy use, and net energy generation would be similar (less than 1% change). Long-term average decrease of 13.5 GWh in net energy generation for the CVP and SWP. Long-term average decrease of TRD generation by 7 GWh (1% change), with a maximum decrease of 9.8 GWh (2.5% change) in critical years.	None needed
Alternative 2	CVP and SWP annual energy generation, energy use, and net energy generation would be similar (less than 1% change). Long-term average decrease of 3.7 GWh in net energy generation for the CVP and SWP. No long-term average change in TRD generation (0% change), with a maximum decrease of 5.2 GWh (0.6% change) in wet years and a maximum increase of 9.8 GWh (1.4% change) in below normal years.	None needed

Key:
% = percent
CVP = Central Valley Project
GWh = gigawatt-hour
SWP = State Water Project

Potential Mitigation Measures

Mitigation measures are presented in this section to avoid, minimize, rectify, reduce, eliminate, or compensate for adverse environmental effects of action alternatives as compared to the No Action Alternative.

Changes under action alternatives as compared to the No Action Alternative would result in similar energy generation, energy use, and net energy generation at CVP and SWP power facilities. Therefore, there would be no adverse impacts to energy resources as compared to the No Action Alternative, and no mitigation measures are needed.

Cumulative Effects Analysis

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 energy resources is summarized in Table 9-14. The methodology for this cumulative effects analysis is described in the Cumulative Effects Technical Appendix.

Table 9-14. Summary of Cumulative Effects on Energy Resources of Alternatives 1 and 2 as Compared to the No Action Alternative

Scenarios	Cumulative Effects of Actions
No Action Alternative with Associated Cumulative Effects Actions in Year 2030	*Conditions and Actions included in Quantitative Analyses* *(Conditions and actions incorporated into No Action modeling)* Climate change and sea level rise, development under the general plans, FERC relicensing projects, and some future projects to improve water quality or habitat are anticipated to reduce carryover storage in reservoirs and change in stream flow patterns in a manner that would likely reduce hydropower generation at CVP and SWP reservoirs. Reduced CVP and SWP water deliveries would also reduce CVP and SWP energy use (e.g. pumping requirements). *Additional Identified Actions* *(Additional reasonably foreseeable projects or actions identified in Cumulative Effects Technical Appendix)* Removal of the four PacifiCorp dams on the mainstem of the Klamath River would reduce hydropower generation year round. Other additional identified actions (e.g., FERC relicensing projects) are also anticipated to reduce hydropower generation.
Alternative 1 with Associated Cumulative Effects Actions in Year 2030	*Alternative 1 with Conditions and Actions included in Quantitative Analyses* Implementation of Alternative 1 would result in reduced net hydropower generation as compared to the No Action Alternative, potentially contributing to cumulative impacts to energy resources. *Alternative 1 with Additional Identified Actions* Alternative 1 with the additional reasonably foreseeable actions would result in reduced net hydropower generation, potentially contributing to cumulative impacts to energy resources.
Alternative 2 with Associated Cumulative Effects Actions in Year 2030	*Alternative 2 with Conditions and Actions included in Quantitative Analyses* Implementation of Alternative 2 would result in reduced net hydropower generation as compared to the No Action Alternative, potentially contributing to cumulative impacts to energy resources. *Alternative 2 with Additional Identified Actions* Alternative 2 with the additional reasonably foreseeable actions would result in reduced net hydropower generation, potentially contributing to cumulative impacts to energy resources.

Key:
CVP = Central Valley Project
FERC = Federal Energy Regulatory Commission
SWP = State Water Project

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Chapter 10
Air Quality, Greenhouse Gas Emissions, and Global Climate Change

Introduction

This chapter describes the potential for greenhouse gas (GHG) emissions that could occur as a result of implementing the alternatives evaluated in this Environmental Impact Statement (EIS). For reasons presented below, air quality-related impacts are dismissed from this EIS. Implementation of the alternatives could affect GHG emissions through operational changes of the Central Valley Project (CVP) and State Water Project (SWP) as a result of augmenting flows in the lower Klamath River.

Air quality impacts can typically be discussed as short-term construction related and long-term operational related. Emissions from construction-related activities typically occur from the use of heavy-duty equipment in the form of exhaust emissions and fugitive dust from earth movement and vehicle travel on unpaved roads. The alternatives do not include construction activities and; therefore, construction-related impacts—associated with criteria air pollutants and precursors, fugitive dust emissions, and exposure of sensitive receptors to air toxics—are not discussed further.

With regards to long-term operational emissions, changes in CVP and SWP operations under the alternatives could change the use of individual engines to operate groundwater wells, resulting in increased use of diesel pumps and associated increases in diesel particulate matter, and criteria air pollutants and precursors. In California, local air districts (e.g., air quality management and air pollution control districts) have been established to oversee the attainment of both the California Ambient Air Quality Standards (CAAQS) and the National Ambient Air Quality Standards (NAAQS) within air basins as defined by the State. Local air districts administer air quality laws and regulations within the air basins. The local air districts have permitting authority over all stationary sources, such as diesel pump engines. Therefore, any proposal to construct, modify, or operate a facility that emits pollutants from stationary sources must obtain either an Authority to Construct permit or an Operating Permit, pursuant to the California and Federal Clean Air Acts. Further, stationary sources of air pollutant emissions that comply with applicable rules and regulations would not be considered to interfere with maintaining or attaining the CAAQS, NAAQS, or General Conformity requirements, as appropriate emissions offsets and emissions controls would be required through the permitting process. For these reasons, long-term increases in diesel-related emissions are not discussed further in this EIS.

Terminology

Important climate change and GHG emission terminology used in this chapter are summarized below:

- **California Ambient Air Quality Standard** – A legal limit that specifies the maximum level and time of exposure in the outdoor air for a given air pollutant, and which is protective of human health and public welfare (California Health and Safety Code section 39606b). CAAQS are recommended by the California Office of Environmental Health Hazard Assessment and adopted into regulation by the California Air Resource Board (ARB). CAAQS are the standards which must be met per the requirements of the California Clean Air Act (ARB 2010).

- **Council on Environmental Quality** – The Council on Environmental Quality (CEQ) was established within the Executive Office of the President by Congress as part of the National Environmental Policy Act (NEPA) of 1969. CEQ coordinates Federal environmental efforts and works closely with agencies and other White House offices in the development of environmental policies and initiatives.

- **Greenhouse Gases** – Atmospheric gases (e.g., carbon dioxide (CO_2), methane (CH_4), hydrofluorocarbons (HFC), nitrous oxide (N_2O), ozone (O_3), perfluorocarbons (PFC), sulfur hexafluoride (SF_6), and water vapor) that slow the passage of re-radiated heat through the Earth's atmosphere (ARB 2010). Six of the GHGs, CO_2, CH_4, N_2O, HFC, PFC, and SF_6, are the subject of reductions under Kyoto Protocol and California Assembly Bill (AB) 32, the California Global Warming Solutions Act of 2006.

- **National Ambient Air Quality Standard** – Standards established by the U.S. Environmental Protection Agency (USEPA) that apply for outdoor air throughout the U.S. (USEPA 2006).

Regulatory Environment and Compliance Requirements

Potential actions implemented under the alternatives evaluated in this EIS could result in possible GHG emissions. Changes in GHG emissions are analyzed in this EIS relative to appropriate Federal and State agency policies and regulations, including:

- CEQ 2016 Guidance on the Consideration of GHG Emissions and the Effects of Climate Change in NEPA Reviews

- AB 32, California Global Warming Solutions Act of 2006

- California Renewables Portfolio Standard (RPS)

- ARB’s California Climate Change Scoping Plan

- Local regulations and policies of California air districts

Council on Environmental Quality 2016 Guidance on the Consideration of Greenhouse Gas Emissions and the Effects of Climate Change in NEPA Reviews

The CEQ has issued final NEPA guidance on the consideration of the effects of climate change and GHG emissions. Issued on August 1, 2016, this guidance advises Federal agencies that they should consider the GHG emissions caused by Federal actions, adapt their actions to consider climate change effects throughout the process, and address these issues in their agency procedures. Where applicable, the scope of the NEPA analysis should cover the GHG emissions effects of a proposed action and alternative actions, as well as the relationship of climate change effects on a proposed action or alternatives.

California Assembly Bill 32, Global Warning Solutions Act of 2006

On September 20, 2006, California adopted the California Global Warming Solutions Act of 2006 (generally referred to as AB 32 and codified in the California Health and Safety Code Section 38500). This law requires ARB to design and implement emission limits, regulations, and other measures such that statewide GHG emissions are reduced in a technologically feasible and cost-effective manner to 1990 levels by 2020 (representing a 25 percent reduction). AB 32 does not directly amend other environmental laws, such as California Environmental Quality Act (CEQA). Instead, it creates a program to identify GHG sources, prioritizes sources for regulation based on significance of contributions to California GHG emissions, and regulates priority sources.

AB 32 establishes a mass emissions threshold of 25,000 metric tons (MT) of carbon dioxide equivalent (CO_2e) per year for mandatory emissions reporting and participation in the cap-and-trade regulatory program for covered entities in California.

California Renewables Portfolio Standard

RPS was established in 2002, under Senate Bill (SB) 1078. The RPS has since been accelerated in 2006, under SB 107, and expanded in 2011, under SB 2. The California Public Utilities Commission (CPUC) and the California Energy Commission jointly implement the RPS program. The RPS program requires investor-owned utilities, electricity providers, and community-choice aggregators to increase procurement from eligible renewable energy resources to 33 percent of total procurement by 2020 (CPUC 2016).

A hydroelectric generation facility of over 30 megawatts (MW) would not be considered an eligible renewable energy resource under SB 1078. Nearly all CVP and SWP facilities discussed in this analysis produce over 30 MW per year and; thus, would not be considered renewable energy resources.

California Climate Change Scoping Plan

On December 11, 2008, pursuant to AB 32, ARB adopted the Climate Change Scoping Plan. This plan outlines how emissions reductions would be achieved from significant sources of GHGs via regulations, market mechanisms, and other actions. Various key elements, outlined in the plan, are identified to achieve emissions reduction targets. Of these, achieving a statewide renewable energy mix of 33 percent through implementation of RPS was identified.

Further, this plan also recommended 39 measures that were developed to reduce GHG emissions from key sources and activities while improving public health, promoting a cleaner environment,

preserving our natural resources, and ensuring that the impacts of the reductions are equitable and do not disproportionately impact low-income and minority communities. These measures also put the State on a path to meet the long-term 2050 goal of reducing California's GHG emissions to 80 percent below 1990 levels. ARB is currently working on an update to this plan.

California Air Districts

There are 35 air districts in California that are responsible for promulgating rules and regulations for the purpose of meeting CAAQS and NAAQS. ARB is responsible for monitoring the regulatory activity of the air districts.

Affected Environment

This section describes the area of analysis and GHG emissions in the study area.

Existing Greenhouse Gases and Emissions Sources

This subsection presents an overview of the greenhouse effect and climate change, potential sources of GHG emissions, and information related to climate change and GHG emissions in California. GHG emissions and their climate-related impacts are not limited to specific geographic locations, but occur on global and regional scales. GHG emissions contribute cumulatively to the overall heat-trapping capability of the atmosphere, and the effects of warming (such as climate change) are manifested in different ways across the planet.

Greenhouse Gas Emissions Regulations and Analyses

Global warming is the name given to the increase in the average temperature of Earth's near-surface air and oceans—since the mid-20th century—and its projected continuation. According to the California Department of Water Resources (DWR), warming of the climate system is now considered to be unequivocal (DWR 2010) with the global surface temperature increase of approximately 1.33 degrees Fahrenheit (°F) over the last one-hundred years. Continued warming is projected to increase global average temperature between 2 and 11°F over the next one-hundred years.

The causes of this warming have been identified as both natural processes and as the result of human actions. The Intergovernmental Panel on Climate Change (IPCC) concludes that variations in natural phenomena (such as solar radiation and volcanoes) produced most of the warming from pre-industrial times to 1950, and had a small cooling effect afterward. However, after 1950, increasing GHG concentrations resulting from human activity—such as fossil fuel burning and deforestation—have been responsible for most of the observed temperature increase. These basic conclusions have been endorsed by more than 45 scientific societies and academies of science, including all of the national academies of science of the major industrialized countries.

Increases in GHG concentrations in Earth's atmosphere are thought to be the main cause of human-induced climate change. GHGs naturally trap heat by impeding the exit of solar radiation that has hit Earth and is reflected back into space. Some GHGs occur naturally, and are necessary for keeping Earth's surface inhabitable. However, increases in the concentrations of these gases in the atmosphere during the last one-hundred years have decreased the amount of solar radiation

that is reflected back into space, intensifying the natural greenhouse effect and resulting in the increase of global average temperature (DWR 2010).

The principal GHGs considered in this EIS are CO_2, CH_4, and N_2O in accordance with the California Health and Safety Code Section 38505(g) (DWR 2010). Each of the principal GHGs has a long atmospheric lifetime (one year to several thousand years). In addition, the potential heat-trapping ability of each of these gases varies significantly from one another, and also varies over time. For example, CH_4 is twenty-five times as potent as CO_2 (IPCC 2007).

The primary anthropogenic processes that release these gases include: burning of fossil fuels for transportation, heating and electricity generation; agricultural practices that release CH_4, such as livestock grazing and crop residue decomposition; and industrial processes that release smaller amounts of high global warming potential gases such as SF_6, PFCs, and HFCs— none of which are applicable to the action alternatives (DWR 2010). Deforestation and land cover conversion have also been identified as contributing to global warming by reducing Earth's capacity to remove CO_2 from the air, altering Earth's albedo or surface reflectance, allowing more solar radiation to be absorbed.

An Overview of the Greenhouse Effect

The greenhouse effect is a natural phenomenon that is essential to keeping Earth's surface warm (DWR 2010). Like a greenhouse window, GHGs allow sunlight to enter, and then prevent heat from leaving the atmosphere. Solar radiation enters Earth's atmosphere from space. A portion of this radiation is reflected by particles in the atmosphere back into space, and a portion is absorbed by Earth's surface and emitted back into space. The portion absorbed by Earth's surface and emitted back into space is emitted as lower-frequency infrared radiation. This infrared radiation is absorbed by various GHGs present in the atmosphere. While these GHGs are transparent to the incoming solar radiation, they are effective at absorbing infrared radiation emitted by Earth's surface. Therefore, some of the lower-frequency infrared radiation emitted by Earth's surface is absorbed and reflected, causing a warming of the atmosphere and earth surfaces.

Global Climate Trends and Associated Impacts The rate of increase in global average surface temperature over the last one-hundred years has not been consistent (DWR 2010). The last three decades have warmed at a much faster rate than the previous seven decades—on average 0.32°F per decade. Eleven of the twelve years from 1995 to 2006, rank among the twelve warmest years in the instrumental record of global average surface temperature since 1850.

Increased global warming has occurred concurrent with many changes that have occurred in other natural systems (DWR 2010). Global sea levels have risen on average 1.8 millimeters per year; precipitation patterns throughout the world have shifted, with some areas becoming wetter and others drier; tropical storm activity in the North Atlantic has increased; peak-runoff timing of many glacial and snow fed rivers has shifted earlier; as well as numerous other observed conditions. Though it is difficult to prove a definitive cause-and-effect relationship between global warming and other observed changes to natural systems, there is high confidence within the scientific community that these changes are a direct result of increased global temperatures.

Overview of Greenhouse Gas Emission Sources Naturally occurring GHGs include water vapor, CO_2, CH_4, and N_2O. Water vapor is introduced to the atmosphere from oceans and the natural biosphere. According to the National Academy of Sciences (NAS), water vapor introduced directly to the atmosphere, primarily from ocean evaporation is not long lived, and thus does not contribute substantially to a warming effect (NAS 2005). Carbon and nitrogen contained in CO_2, CH_4, and N_2O naturally cycle from gaseous forms to organic biomass through processes such as plant and animal respiration, and seasonal cycles of plant growth and decay (USEPA 2012). Although naturally occurring, the emissions and sequestration of these gases are also influenced by human activities, and in some cases, are caused by human activities. In addition to these GHGs, several classes of halogenated substances that contain fluorine, chlorine, or bromine also contribute to the greenhouse effect. These compounds are, for the most part, the product of industrial activities.

In addition to these natural sources of GHG emissions, CO_2, a byproduct of burning fossil fuels and biomass, as well as land-use changes and other industrial processes is the primary source of anthropogenic GHG emissions (USEPA 2012). It is the principal anthropogenic GHG that contributes to Earth's radiative balance, and it represents the dominant portion of GHG emissions from activities that result from the combustion of fossil fuels (e.g., construction activities, electrical generation and transportation).

Each of the GHGs has a different capacity to trap heat in the atmosphere, with some of these gases being more effective at trapping heat than others. For calculating emissions, ARB (ARB 2016b) uses a metric developed by IPCC to account for these differences and to provide a standard basis for calculations. The metric, called the global warming potential (GWP), is used to compare the future climate impacts of emissions of various long-lived GHGs. The GWP of each GHG is indexed to the heat-trapping capability of CO_2, and allows comparison of the global warming influence of each GHG relative to CO_2. The GWP is used to translate emissions of each GHG to emissions of CO_2e. In this way, emissions of various GHGs can be summed, and total GHG emissions can be inventoried in common units of MT per year of CO_2e. Most international inventories, including the U. S. inventory, use GWP values from the IPCC Fourth Assessment Report, per international consensus (IPCC 2007).

California Climate Trends and Greenhouse Gas Emissions

According to the IPCC, global average temperature is expected to increase relative to the 1986–2005 period by 0.3–4.8 degrees Celsius (°C) (0.5-8.6 °F) by the end of the 21st century (2081-2100), depending on future GHG emission scenarios (IPCC 2014). According to U.S. Department of the Interior, Bureau of Reclamation (Reclamation), climate change models indicate temperatures throughout the Klamath River Basin may increase by approximately 5 to 6°F (Reclamation 2016b). In the Central Valley, temperature is also projected to increase steadily during the century, with changes generally higher farther away from the coast, reflecting a continued ocean cooling influence.

Another outcome of global climate change is sea-level rise. The average global sea level rose approximately 6.7-7.9 inches during the last century. According to the National Research Council (NRC)'s recent comprehensive assessment of sea level change projections for Pacific Coast, sea level along the State's coastline could be and one foot higher than 2000 levels by 2050, and about three feet higher than 2000 levels the end of this century (Reclamation 2016b).

Potential Effects of Global Climate Change in California Warming of the atmosphere has broad implications for the environment. In California, one of the effects of climate change could be increases in temperature that could affect the timing and quantity of precipitation. California receives most of its precipitation in the winter months, and a warming environment would raise the elevation of snow pack and result in reduced spring snowmelt and more winter runoff. These effects on precipitation and water storage in the snow pack could have broad implications on the environment in California.

Reclamation recently completed two reports on water resources in the West. These reports examine potential future impacts using projected 21st-century climate changes. Following are some of the potential effects of a warming climate in California, as described in the reports (Reclamation 2016a, 2016b):

- Loss of snowpack storage will cause increased winter runoff, which generally would not be captured and stored because of the need to reserve flood capacity in reservoirs during the winter. By the end of the century, higher-elevation portions of the watershed may see a decrease of 70 percent in annual snowpack.

- Less spring runoff would mean lower early-summer storage at major reservoirs, which would result in less hydroelectric power production.

- Higher temperatures and reduced snowmelt would compound the problem of providing suitable cold-water habitat for salmonid species. Lower reservoir levels would also contribute to this problem, reducing the flexibility of cold-water releases.

- Sea-level rise would affect the Sacramento-San Joaquin River Delta (Delta), worsening existing levee problems, causing more saltwater intrusion, and adversely affecting many coastal marshes and wildlife reserves. Release of water to streams to meet water quality requirements required existing laws and regulations could further reduce storage levels.

- Increased temperatures may increase the agricultural demand for water and increase the level of stress on native vegetation, potentially allowing for an increase in pest and insect epidemics, and a higher frequency of damaging wildfires.

- Greater variability in precipitation would result in a 20 percent higher flood potential under a warm-wet climate scenario, and a 364 percent greater potential for drought in a hot-dry climate scenario. The increased intensity of droughts and floods raises concerns about infrastructure safety, the resiliency of species and ecosystems to these changes, and the ability to maintain adequate levels of hydropower production.

Current California Emission Sources The most recent California GHG emission inventory was released on March 30, 2016, with data updated through 2014. The GHG emissions in California have been estimated each year from 2000 to 2014, and are reported for several large sectors of emission sources. The 2014 estimates are summarized in Table 10-1, reported by sector as millions of tons per year of CO_2e (ARB 2016a, 2016b).

Table 10-1. California Greenhouse Gas Emissions by Sector in 2014

Sector	Total Emissions[1] (million tons/year of CO_2e)	Percent of Statewide Total Gross Emissions[2]
Agriculture and Forestry	36.1	7.9
Commercial and Residential	49.0	10.7
Electric Power[3]	88.4	19.3
Industrial	104.2	22.8
Transportation	163.0	35.6
High Global Warming Potential substance and ozone-depleting substance use	17.1	3.7
Total	457.85	100

Source: ARB 2016a; 2016b.
Notes:
[1] Inventory reporting methodology change initiated by ARB no longer accounts for carbon sequestration.
[2] Based on the 457.85 million tons/year of CO_2e Total Gross Emissions estimate.
[3] Includes in-state-generated and imported electricity production.
Key:
ARB = Air Resources Board
CO_2e = carbon dioxide equivalent

Total gross statewide GHG emissions in 2014 were estimated to be 457.85 million tons per year of CO_2e. The two largest sectors contributing to emissions in California are transportation and industrial. The agricultural sector—which includes manure management, enteric fermentation, agricultural residue burning, soils management, and forestry—represents only 7.9 percent of the total gross statewide emissions.

Central Valley Project and State Water Project Study Area

The CVP is composed of 18 reservoirs with a combined storage capacity of more than 11 million acre-feet, 10 hydroelectric power plants, and more than 500 miles of major canals and aqueducts. The major CVP reservoirs are in the Sacramento and San Joaquin River basins, including Shasta Lake on the Sacramento River, Folsom Lake on the American River, New Melones Reservoir on the Stanislaus River, and Millerton Lake on the San Joaquin River. The CVP also diverts water from Trinity Lake (on the Trinity River) to the Sacramento River system via Clear Creek Tunnel. CVP pumping plants and canals include the Red Bluff Pumping Plant, which diverts water from the Sacramento River into the CVP Tehama-Colusa Canal; Folsom South Canal, which conveys water from Folsom Lake to southeastern Sacramento County; Contra Costa Canal Pumping Plant, which diverts water from Rock Slough in the Delta into the CVP Contra Costa Canal; and C.W. Jones Pumping Plant, which diverts water from the south Delta into the CVP Delta-Mendota Canal.

The SWP includes a reservoir on the Feather River near Oroville (Lake Oroville), a Delta cross channel, an electric power transmission system, an aqueduct to convey water from the Delta to Solano and Napa Counties (North Bay Aqueduct), an aqueduct to convey water from the Delta to the San Francisco Bay Area (South Bay Aqueduct), an aqueduct (California Aqueduct) with the San Luis Dam to convey water from the Delta to the San Joaquin Valley and southern California, and several reservoirs in southern California.

As discussed below in further detail, GHG emissions could result from increases in indirect electricity generation replacing net decreases in hydroelectric generation between the CVP and

SWP, as well as from potential increases in the use of alternative local water sources (i.e., groundwater pumping) as changes in the CVP and SWP affect water deliveries. As such, GHG emissions would occur indirectly through energy generation or directly at local diesel pumps used for ground water pumping. Specific locations of these facilities and sources are unknown and; therefore, it is assumed that GHG emissions could occur anywhere within California.

Impact Analysis

This section describes the potential mechanisms and analytical methods for changes in GHG emissions, results of the impact analysis and cumulative effects.

Potential Mechanisms for Change and Analytical Methods and Assumptions

The impact analysis considers changes in GHG emissions related to changes in CVP and SWP operations under the alternatives, as compared to the No Action Alternative.

As discussed in Chapter 2, “Description of Alternatives,” with regards to climate change further exacerbating identified impacts, the No Action Alternative assumes future conditions such as climate change and sea-level rise. As such, impacts discussed throughout this EIS, from various resources, address the impacts associated with climate change.

Changes in Greenhouse Gas Emissions Due to Changes in Energy Generation or Use

Changes in CVP and SWP operations under the alternatives could change energy generation and use, and associated GHG emissions. In addition, operational changes could also affect the use of energy by CVP and SWP water users through the implementation of regional and local alternative water supplies, such as recycling or desalination. When CVP and SWP water deliveries decline, CVP and SWP net energy generation changes; and water users would likely increase their use of groundwater, recycled water, and desalinated water from existing facilities, or facilities that are reasonably foreseeable to be constructed by 2030. When CVP and SWP water deliveries increase, CVP and SWP net energy generation would change. Water users are anticipated to reduce their use of alternate water supplies either due to economic considerations or to allow the amount of stored water to increase under a conjunctive-use pattern. It is not known whether the changes in CVP and SWP net energy generation would be similar to the changes in energy use for alternate regional and local water supplies. Local water supply could include groundwater pumping, recycled water, desalination, or surface water from local water purveyors. Energy intensity for water conveyance and supply varies depending on several factors such as water source type, fuel source used for pumping and conveyance facilities, as well as distance water is conveyed. Information is not available to determine what types of local water supplies would be utilized, how much local water is needed, and how much energy would be required for distributing water. As such, GHG emissions associated with potential increases in energy use from local alternative water supplies are not quantified or evaluated further, as such would be speculative.

Changes in the timing and magnitude of net CVP and SWP hydroelectric generation would result in changes in GHG emissions. Increased net CVP and SWP hydroelectric generation would reduce the need for electricity generated through fossil fuel combustion, and would avoid the GHG emissions that result from fossil fuel use. In comparison, reduced hydroelectric generation

would increase the need for other types of electricity production, including electricity generated from fossil fuels, with the result that GHG emissions would increase. As such, for purposes of this GHG analysis, it is assumed that net reduction in hydroelectric generation would result in GHG emissions at a one-to-one ratio.

Operational GHG emissions were estimated in accordance with industry-approved methods and assumptions. GHG emission estimates were based on the net change in hydroelectric generation between the CVP and SWP for each action alternative, in comparison to the No Action Alternative. Total net annual energy consumption/generation was simulated using the LTGen and SWP_Power based on CalSim II model outputs. Each action alternative includes multiple water-year types, based on hydrologic conditions. The Analytical Tools Technical Appendix provides additional information on the assumptions used in these analyses, including assumptions regarding climate change and sea level rise.

The 2016 Guidance on the Consideration of Greenhouse Gas Emissions and the Effects of Climate Change in NEPA Reviews, released by CEQ, recommends using a frame of reference when discussing the impacts of GHG emissions. While there is no threshold of significance determined by CEQ, it is recommended to use relevant policies for GHG emissions reductions (CEQ 2016).

One of the more commonly suggested mass emissions thresholds is 25,000 MT CO_2e per year. This value is the threshold established for mandatory emissions reporting for most sources in California, under AB 32 and is used to provide further context regarding the magnitude of GHG emission estimates under the action alternatives.

In addition to consideration of available numeric thresholds, implementation of each of the action alternatives was evaluated in the context of California's RPS and Scoping Plan, adopted for the purpose of reducing GHG emissions statewide.

Evaluation of Alternatives

The action alternatives have been compared to the No Action Alternative.

No Action Alternative

Changes in Greenhouse Gas Emissions Due to Changes in Energy Generation or Use The No Action Alternative assumes continued implementation of existing projects, plans, ecosystem restoration projects (e.g., Trinity River Restoration Program (TRRP)), land or resource management plans, water supply management and wastewater facilities, flood management facilities, and recreational facilities. The No Action Alternative assumes future conditions such as climate change and sea-level rise, development of lands in accordance with general plans in areas served by CVP water supplies, and continued operation of the CVP to the year 2030.

For the Klamath River Basin, temperatures and precipitation are both anticipated to increase. Climate change may also cause changes in stream flows in the Klamath Basin. Projected warming is anticipated to change runoff timing, with more rainfall runoff during the winter and less runoff during the late spring and summer. It is anticipated these changes in river flows will change annual hydropower generation patterns, including reducing generation in the late-spring and summer.

For the Central Valley, it is anticipated that climate change would result in warmer temperatures, 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. It is anticipated that changes in reservoir storage levels and release patterns will reduce CVP and SWP generation. Declines in CVP and SWP water supply deliveries would result in reduced energy requirements for conveyance of water supplies to CVP and SWP contractors.

It was assumed that a net reduction in hydroelectric generation between the CVP and SWP would result in GHG emissions associated with replaced energy derived from fossil fuels. Annual GHG emissions were estimated for the No Action Alternative for each water-year type. Table 10-2 provides a summary of net energy generation and associated GHG emissions for the No Action Alternative.

The No Action Alternative would result in GHG emissions associated with the potential replacement of hydroelectric generation by fossil fuel electricity sources when net hydroelectric generation is negative. However, emissions associated with electricity generation throughout the State have been accounted for in the State GHG inventory and subsequent GHG reduction goals outlined by the Scoping Plan and RPS. Further, hydroelectric power generated by CVP/SWP facilities is not counted towards RPS, so replacing it with fossil fuel generated electricity (which also would not count towards RPS) would not affect the ability of energy utilities, or the State, to meet RPS, and subsequently AB 32 and Scoping Plan goals.

Table 10-2. No Action Alternative Net Hydroelectric Generation and Associated GHG Emissions

Water Year	Net CVP Hydroelectric Generation (GWh/year)	CVP GHG Emissions (MT CO_2e/year)[1]	Net SWP Hydroelectric Generation (GWh/year)	SWP GHG Emissions (MT CO_2e/year)[1]	Net GHG Emissions (MT CO_2e/year)
Wet	4,740	-2,369,793	-4,079	2,039,282	N/A[2]
Above Normal	3,840	-1,920,160	-3,981	1,990,528	70,369
Below Normal	3,081	-1,540,314	-4,209	2,104,708	564,394
Dry	2,669	-1,334,404	-3,428	1,713,961	379,556
Critical	2,042	-1,020,920	-2,062	1,030,962	10,042
Average All Years	3,475	-1,737,308	-3,627	1,813,424	76,115

Notes:
[1] Net positive hydrogenation in either the CVP or the SWP is assumed to result in no additional GHG emissions and is therefore presented as negative emissions for comparison purposes among the CVP and the SWP annual hydroelectric generation.
[2] When reporting net GHG emissions, the net change or increase in GHG emissions between action alternative are considered for impact determinations and thus when net negative emissions occur, no GHG emissions are presented.
Key:
CO_2e = carbon dioxide equivalent
CVP = Central Valley Project
GHG = Greenhouse Gas
GWh = gigawatt-hour
MT = metric tons
N/A = not applicable
SWP = State Water Project

Proposed Action (Alternative 1)

Alternative 1 is compared to the No Action Alternative.

Changes in GHG Emissions Due to Changes in Energy Generation or Use As described in Chapter 9, "Hydropower Generation," CVP and SWP operations under Alternative 1 would result in various changes to pumping and total hydroelectric generation. In general, net hydroelectric generation between the CVP and the SWP under Alternative 1 would decrease in comparison to the No Action Alternative. As a result, under the assumption that a net decrease in hydroelectric generation would result in additional indirect GHG emissions associated with replaced fossil fuel generated electricity, Alternative 1 would result in additional GHG emissions compared to the No Action Alternative.

As described above, it was assumed that a net reduction in hydroelectric generation would result in GHG emissions associated with replaced energy derived from fossil fuels. Annual GHG emissions were estimated for Alternative 1 for each water year. Table 10-3 provides a summary of net energy generation and associated GHG emissions for Alternative 1 compared to the No Action Alternative.

Table 10-3. Alternative 1 Hydroelectric Generation and Associated GHG Emissions Compared to the No Action Alternative

	CVP			SWP			Net
Water Year	**Net Hydro-electric Generation (GWh/ year)**	**Change in Net Generation Compared to No Action (GWh/ year)**	**GHG Emissions (MT CO_2e/ year)** [1]	**Net Hydro-electric Generation (GWh/ year)**	**Change in Net Generation Compared to No Action (GWh/ year)**	**GHG Emissions (MT CO_2e/ year)** [1]	**GHG Emissions (MT CO_2e/ year)**
Wet	4,723	-16	8,117	-4,083	-5	2,465	10,581
Above Normal	3,837	-3	1,621	-3,983	-2	924	2,545
Below Normal	3,085	5	-2,327	-4,206	4	-1,871	N/A[1]
Dry	2,660	-9	4,654	-3,429	-1	720	5,373
Critical	2,022	-20	9,822	-2,073	-11	5,304	15,127
Average All Years	3,464	-10	5,091	-3,630	-3	1,629	6,720

Notes:
[1] When reporting net GHG emissions, the net change or increase in GHG emissions between action alternative are considered for impact determinations and thus when net negative emissions occur, no GHG emissions are presented.
Key:
CO_2e = carbon dioxide equivalent
CVP = Central Valley Project
GHG = Greenhouse Gas
GWh = gigawatt-hour
MT = metric tons
N/A = not applicable
SWP = State Water Project

Based on the modeling conducted, increases in GHG emissions associated with implementation of Alternative 1, in comparison to the No Action Alternative, could be as high as 15,127 MT CO_2e per year. Considering available guidance with respect to GHG emissions – 25,000 MT CO_2e per year, as discussed above – this level of emissions would not be considered substantial. Further, although GHG emissions would increase as fossil fuel generation replaces hydroelectric generation, individual utilities within California would still be required to achieve RPS goals. As hydroelectric power generated by CVP/SWP facilities is not counted towards RPS, replacing it with fossil fuel generated electricity (which also would not count towards RPS) would not affect the ability of energy utilities, or the State, to meet RPS, and subsequently AB 32 and Scoping Plan goals.

Trinity River Record of Decision Flow Rescheduling Alternative (Alternative 2)

Alternative 2 is compared to the No Action Alternative.

Changes in Greenhouse Gas Emissions Due to Changes in Energy Generation or Use As described in Chapter 9, "Hydropower Generation," CVP and SWP operations under Alternative 2 would result in various changes to pumping and total hydroelectric generation. Under certain water conditions (i.e., wet and dry years), net hydroelectric generation between the CVP and the SWP under Alternative 2 would decrease in comparison to the No Action Alternative. As a result, under the assumption that a net decrease in hydroelectric generation would result in additional indirect GHG emissions associated with replaced fossil fuel generated electricity,

Alternative 2 would result in additional GHG emissions compared to the No Action Alternative during wet and dry years.

As described above, it was assumed that a net reduction in hydroelectric generation would result in GHG emissions associated with replaced energy derived from fossil fuels. Annual GHG emissions were estimated for Alternative 2 for each water-year scenario. During years where a net positive hydroelectric generation is expected, no additional GHG emissions would occur. Table 10-4 provides a summary of net energy generation and associated GHG emissions for Alternative 2 compared to the No Action Alternative.

Table 10-4. Alternative 2 Hydroelectric Generation and Associated GHG Emissions Compared to the No Action Alternative

	CVP			SWP			Net
Water Year	**Net Hydro-electric Generation (GWh/ year)**	**Change in Net Generation Compared to No Action (GWh/ year)**	**GHG Emissions (MT CO_2e/ year)[1]**	**Net Hydro-electric Generation (GWh/ year)**	**Change in Net Generation Compared to No Action (GWh/ year)**	**GHG Emissions (MT CO_2e/ year)**	**GHG Emissions (MT CO_2e/ year)**
Wet	4,730	-10	4,884	-4,083	-4	2,070	6,954
Above Normal	3,846	5	-2,694	-3,982	0	222	N/A[2]
Below Normal	3,094	13	-6,506	-4,206	3	-1,641	N/A[2]
Dry	2,666	-3	1,573	-3,432	-4	2,118	3,691
Critical	2,039	-2	1,189	-2,063	-1	428	1,617
Average All Years	3,473	-2	807	-3,629	-2	1,051	1,857

Notes:

[1] Net positive hydrogenation in either the CVP or the SWP is assumed to result in no additional GHG emissions and is therefore presented as negative emissions for comparison purposes among the CVP and the SWP annual hydroelectric generation.

[2] When reporting net GHG emissions, the net change or increase in GHG emissions between action alternative are considered for impact determinations and thus when net negative emissions occur, no GHG emissions are presented.

Key:
CO_2e = carbon dioxide equivalent
CVP = Central Valley Project
GHG = Greenhouse Gas
GWh = gigawatt-hour
MT = metric tons
N/A = not applicable
SWP = State Water Project

Based on the modeling conducted, increases in GHG emissions associated with implementation of Alternative 2, in comparison to the No Action Alternative, could be as high as 6,954 MT CO_2e per year in wet years. Considering available guidance with respect to GHG emissions – 25,000 MT CO_2e per year, as discussed above – this level of emissions would not be considered substantial. Further, although GHG emissions would increase as fossil fuel generation replaces hydroelectric generation, individual utilities within the State would still be required to achieve RPS goals. As hydroelectric power currently is not counted towards RPS, replacing it with fossil

fuel generated electricity (which also would not count towards RPS) would not affect the ability of energy utilities or the State to meet RPS, and subsequently AB 32 and Scoping Plan goals.

Summary of Impact Analysis

Table 10-5 compares the changes in GHG emissions of implementing the action alternatives compared to the No Action Alternative. Alternative 1 would result in an increase in GHG emissions under each water year type, except for below normal water years. In years with increased emissions, those increases ranged from 2,545 MT to 15,127 MT CO_2e per year. Alternative 2 would result in an increase in GHG emissions under each water year when compared to the No Action Alternative, except for above normal and below normal water years. In years with increased emissions, those increases ranged from 1,617 MT in critical years to 6,954 MT CO_2e per year in wet years. In each instance, for the reasons discussed under the *Evaluation of Alternatives*, the increase over the No Action Alternative would not be considered substantial. Table 10-6 compares the environmental consequences of implementing the action alternatives compared to the No Action Alternative.

Table 10-5. Comparison of Increase in GHG Emissions from Alternatives 1 and Alternative 2 Compared to the No Action Alternative

Water Year	No Action Alternative (MT CO_2e/year)	Net Increase in GHG Emissions Under Alternative 1 (MT CO_2e/year)[1]	Net Increase in GHG Emissions Under Alternative 2 (MT CO_2e/year)[1]
Wet	N/A[2]	10,581	6,954
Above Normal	70,369	2,545	N/A[2]
Below Normal	564,394	N/A[2]	N/A[2]
Dry	379,556	5,373	3,691
Critical	10,042	15,127	1,617
Average All Years	76,115	6,720	1,857

Notes:
[1] GHG emissions are presented as an increase in emissions compared to the No Action Alternative.
[2] No GHG emissions associated with positive net hydroelectric generation.
Key:
CO_2e = carbon dioxide equivalent
CVP = Central Valley Project
GHG = Greenhouse Gas
GWh = gigawatt-hour
MT = metric tons
N/A = not applicable
SWP = State Water Project

Table 10-6. Comparison of Action Alternatives to No Action Alternative

Alternative	Potential Change	Consideration for Mitigation Measures
Alternative 1	Average annual increase in GHG emissions of 6,720 MT CO_2e in comparison to the No Action Alternative.	None needed
Alternative 2	Average annual increase in GHG emissions of 1,857 MT CO_2e in comparison to the No Action Alternative.	None needed

Key:
CO_2e = carbon dioxide equivalent
GHG = Greenhouse Gas
MT = metric tons

Potential Mitigation Measures

As discussed under the Evaluation of Alternatives, implementation of Alternative 1 or Alternative 2 would not result in increases in GHG emissions as compared to the No Action Alternative that, when considering available guidance – 25,000 MT CO_2e per year, as discussed above – would be substantial. Further, the action alternatives and No Action Alternative do not conflict with existing plans and policies such as the RPS and the Scoping Plan. No mitigation measures are proposed.

Cumulative Effects Analysis

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 action alternatives for GHG emissions is summarized in Table 10-7. The methodology for this cumulative effects analysis is described in the Cumulative Effects Technical Appendix.

As described in the *Affected Environment*, GHG emissions are global pollutants and therefore contribute to a global—not local or regional—problem. Based on the global nature of GHG emissions, the global climate change analysis is inherently cumulative. Indirect emissions as a result of the alternatives would be cumulative contributions to a global issue. The regulatory framework in the State sets California GHG reduction targets (i.e., goals set by the Scoping Plan) that are to be met.

Table 10-7. Summary of Cumulative Effects on Greenhouse Gas Emissions of Action Alternatives as Compared to the No Action Alternative

Scenarios	Cumulative Effects of Actions
No Action Alternative with Associated Cumulative Effects Actions in Year 2030	*Conditions and Actions included in Quantitative Analyses* *(Conditions and actions incorporated into No Action Alternative modeling)* Climate change and sea-level rise, development under the general plans, FERC relicensing projects, and some future projects to improve water quality or habitat are anticipated to reduce carryover storage in reservoirs and change stream flow patterns as compared to past conditions. These factors could reduce hydroelectric generation, which could result in increased use of fossil fuels, indirectly increasing GHG emissions for fossil fuel generation, and increased use of diesel engines for additional groundwater use. *Additional Identified Actions* *(Additional reasonably foreseeable projects or actions identified in Cumulative Effects Technical Appendix)* Removal of the four PacifiCorp dams on the mainstem of the Klamath River would reduce hydroelectric generation. Other additional identified actions (e.g., FERC relicensing projects) are also anticipated to reduce hydropower generation. These reductions in hydropower generation could result in increased use of fossil fuels and indirectly increase GHG emissions for fossil fuel generation.
Alternative 1 with Associated Cumulative Effects Actions in Year 2030	*Alternative 1 with Conditions and Actions included in Quantitative Analyses* Implementation of Alternative 1 could result in increased GHG emissions as compared to the No Action Alternative. Indirect GHG emissions as a result of Alternative 1 could be cumulative contributions to a global issue. *Alternative 1 with Additional Identified Actions* Alternative 1 with the additional reasonably foreseeable actions could result in increased GHG emissions. Indirect GHG emissions as a result of Alternative 1 and the additional reasonably foreseeable actions could be cumulative contributions to a global issue.
Alternative 2 with Associated Cumulative Effects Actions in Year 2030	*Alternative 2 with Conditions and Actions included in Quantitative Analyses* Implementation of Alternative 2 could result in increased GHG emissions as compared to the No Action Alternative. Indirect GHG emissions as a result of Alternative 2 could be cumulative contributions to a global issue. *Alternative 2 with Additional Identified Actions* Alternative 2 with the additional reasonably foreseeable actions could result in increased GHG emissions. Indirect GHG emissions as a result of Alternative 2 and the additional reasonably foreseeable actions could be cumulative contributions to a global issue.

Key:
FERC = Federal Energy Regulatory Commission
GHG = greenhouse gas

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Chapter 11
Agricultural Resources

Introduction

Agricultural resources in the study area could see potential changes occur as a result of implementing the alternatives evaluated in this Environmental Impact Statement (EIS). Implementation of the alternatives could affect these resources through operational changes of the Central Valley Project (CVP) and State Water Project (SWP).

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 operations may occur in the Central Valley and Bay-Delta Region. Direct agricultural resource effects from implementation of the alternatives analyzed in this EIS are related to changes in agricultural land uses due to the availability and reliability of CVP water supplies. An overview of California agriculture follows, with agricultural resources information for each of the potentially affected regions.

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 82 commodities; and produces more than 99 percent of the nation's almonds, artichokes, dates, figs, raisins, kiwifruit, olives, clingstone peaches, pistachios, prunes, pomegranates, sweet rice, and walnuts (USDA-NASS 2015). In 2013, cultivation of 25.5 million acres of agricultural land contributed about $46.4 billion to California's economy and nearly 12 percent of total agricultural revenues in the United States (USDA-NASS 2015).

Recent trends in California agricultural production include reductions in field and forage crop acreage and increases in orchard and vine acreage (Reclamation 2015). The U.S. Department of Agriculture National Agricultural Statistics Service California Field Office publishes annual reports containing data from County Agricultural Commissioners and periodic statewide censuses 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.

Central Valley and Bay-Delta Region

The Central Valley and Bay-Delta 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 Sacramento-San Joaquin River Delta (Delta) area are included in the description of the Sacramento and San Joaquin Valleys. The Delta counties of Sacramento, Yolo,

and Solano Counties are included within the Sacramento Valley discussion. San Joaquin County is included within the San Joaquin Valley 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.

Sacramento Valley

The Sacramento Valley includes the counties of Shasta, Plumas, Tehama, Glenn, Colusa, Butte, Sutter, Yuba, Nevada, Placer, El Dorado, Sacramento, Yolo, and Solano Counties. Agriculture in other counties in the Sacramento Valley are not anticipated to be affected by changes in CVP 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 11-1. 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 of the total crop value produced. Almonds and walnuts represent the largest acreages in this category. In total, the Sacramento Valley contains nearly two million agricultural acres generating over $4 billion per year in value of production.

Table 11-1. Recent Annual Agricultural Acreage and Value of Production in Sacramento Valley

	Orchards, Vineyards, and Berries	**Field and Forage**	**Livestock, Dairy, and Poultry**	**Nursery, Other**	**Vegetable**	**Total**
Acreage[1,2]	419,263	1,435,923	N/A	1,658	91,684	1,948,527
Value[1,3]	$1,636	$1,648	$528	$141	$336	$4,288

Sources: USDA-NASS 2008, 2009, 2010, 2011, 2012, 2013

Notes:

[1] Annual acreages and values are average annual between 2007 and 2012.

[2] 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.

[3] Values in million dollars, 2016 basis.

Key:

N/A = Not Applicable

San Joaquin Valley

The San Joaquin Valley includes 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 operations, and are not discussed here, including: Calaveras, Mariposa, and Tuolumne Counties.

Field and forage crops are also the largest category by acreage in this region, as summarized in Table 11-2. 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. In total, the San Joaquin Valley contains over 5.5 million irrigated acres, generating over twenty-seven 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. Agricultural producers within these CVP water service contractors and SWP contractors are especially susceptible to large variation in available surface water and imported 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 contractors.

On the east side of the San Joaquin Valley, at the base of the Sierra Nevada, surface water is delivered under water rights on streams from the Sierra Nevada, or by the CVP from Millerton Lake at Friant Dam. 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 San Joaquin River Exchange Contractors under terms of the exchange contract. A number of agricultural areas throughout the valley have no or very low priority surface water rights. Growers in these areas rely more heavily on groundwater for irrigation water.

Table 11-2. Recent Annual Agricultural Acreage and Value of Production in San Joaquin Valley

	Orchards, Vineyards, and Berries	**Field and Forage**	**Livestock, Dairy, and Poultry**	**Nursery, Other**	**Vegetable**	**Total**
Acreage[1,2]	1,943,549	3,078,803	N/A	3,838	510,370	5,536,560
Value[1,3]	$11,380	$3,179	$9,831	$489	$2,908	$27,786

Sources: USDA-NASS2008, 2009, 2010, 2011, 2012, 2013

Notes:

[1] Annual acreages and values are average annual between 2007 and 2012.

[2] 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.

[3] Values in million dollars, 2016 basis.

Key:

N/A = Not Applicable

Impact Analysis

Potential Mechanisms for Change in Agricultural Resources and Analytical Methods

The environmental consequences assessment considers changes in agricultural resource conditions related to changes in CVP operations under the alternatives, as compared to the No Action Alternative.

Changes in Irrigated Agricultural Acreage and Total Production Value

Changes in CVP 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.

The results of the impact analysis represents comparison of long-term changes that would occur between alternatives in 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. 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 Analytical Tools Technical Appendix provides further information on the SWAP model.

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, quantities used, and other inputs. The model also fallows land when that appears to be the most cost-effective response to resource conditions. SWAP produces estimates of the change in value and costs of agricultural production.

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 4, “Surface Water Supply and Management,” were provided as inputs into SWAP through a standardized data linkage procedure. Groundwater elevations are not expected to significantly change with the alternatives, as described in Chapter 6, “Groundwater Resources/Groundwater Quality,” and no changes in pumping lift between the No Action Alternative and the alternatives were made in SWAP.

In addition, the analysis does not restrict groundwater withdrawals based upon groundwater overdraft or groundwater quality conditions. As described in Chapter 6, “Groundwater Resources/Groundwater Quality,” the Sustainable Groundwater Management Act requires preparation of Groundwater Sustainability Plans (GSP) 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 and it was assumed that Central Valley agriculture water users would not restrict groundwater withdrawals by 2030.

Evaluation of Alternatives

The impact analysis in this EIS is based upon the comparison of the alternatives to the No Action Alternative in the year 2030.

No Action Alternative

Potential Changes in Irrigated Agricultural Production Under the No Action Alternative, agricultural resources would be comparable to the conditions described in the *Affected Environment* section of this chapter. Conditions in 2030 would be different than existing conditions, primarily due to climate change and sea-level rise, general plan development throughout California, and implementation of reasonable and foreseeable water resource management projects to provide water supplies. Climate change and sea-level rise are anticipated to reduce long-term average CVP water supply deliveries by 2030, as compared to recent historical long-term average deliveries. These reduced deliveries could result in more crop idling or changes in cropping patterns. Development under general plans would disrupt agricultural resources.

Proposed Action (Alternative 1)

Central Valley and Bay-Delta Region

Potential Changes in Irrigated Agricultural Production in the Sacramento Valley Results of the SWAP analysis indicated that agricultural cropping patterns in the Sacramento Valley would be similar (less than a 1 percent change) 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 11-3 and 11-4.

Table 11-3. 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	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.
Totals may not sum due to rounding.

Table 11-4. 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	543	544	-1
Field Crops	59	59	0
Forage Crops	197	197	0
Vegetables and Truck Crops	119	119	0
Orchards and Vineyards	456	456	0
Total	1,528	1,529	-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.
Totals may not sum due to rounding.

Agricultural production in the Sacramento Valley would be similar (less than a 1 percent change) under Alternative 1 as compared to the No Action Alternative over long-term average conditions and in dry and critical dry years (less than 1 percent change), as summarized in Tables 11-5 and 11-6.

Table 11-5. 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	158	158	0.0
Rice	1,178	1,178	0.0
Field Crops	82	82	0.0
Forage Crops	260	260	0.0
Vegetables and Truck Crops	1,023	1,023	0.0
Orchards and Vineyards	3,375	3,375	0.0
Total	6,076	6,076	0.0

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.
All values of production are in 2016 dollar equivalent values.
Totals may not sum due to rounding.

Table 11-6. 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	158	158	0.0
Rice	1,169	1,170	-1.3
Field Crops	82	82	0.0
Forage Crops	257	257	0.0
Vegetables and Truck Crops	1,022	1,022	0.0
Orchards and Vineyards	3,375	3,375	-0.1
Total	6,064	6,064	-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 2016 dollar equivalent values.
Totals may not sum due to rounding.

Potential Changes in Irrigated Agricultural Production in the 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 (less than 1 percent change) 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 11-7 and 11-8.

Table 11-7. 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.
Totals may not sum due to rounding.

Table 11-8. 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	1,010	1,010	0
Rice	17	17	0
Field Crops	827	827	0
Forage Crops	735	735	0
Vegetables and Truck Crops	633	633	0
Orchards and Vineyards	2,154	2,154	0
Total	5,376	5,376	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.
Totals may not sum due to rounding.

Agricultural production in the San Joaquin Valley would be similar (less than 1 percent change) under Alternative 1 as compared to the No Action Alternative over long-term average conditions and in dry and critical dry years (less than 1 percent change), as summarized in Tables 11-9 and 11-10.

Table 11-9. 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	1,452	1,452	0.0
Rice	33	33	0.0
Field Crops	1,519	1,519	0.0
Forage Crops	1,508	1,508	0.0
Vegetables and Truck Crops	4,889	4,889	0.0
Orchards and Vineyards	17,499	17,499	0.0
Total	26,900	26,900	0.0

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.
All values of production are in 2016 dollar equivalent values.
Totals may not sum due to rounding.

Table 11-10. 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	1,437	1,437	0.0
Rice	33	33	0.0
Field Crops	1,518	1,518	0.0
Forage Crops	1,508	1,508	0.0
Vegetables and Truck Crops	4,888	4,888	0.0
Orchards and Vineyards	17,494	17,494	0.1
Total	26,879	26,879	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 2016 dollar equivalent values.
Totals may not sum due to rounding.

Trinity River Record of Decision Flow Rescheduling Alternative (Alternative 2)

Central Valley and Bay-Delta Region

Potential Changes in Irrigated Agricultural Production in the Sacramento Valley Results of the SWAP analysis indicated that the agricultural cropping pattern in the Sacramento Valley would be similar (less than 1 percent change) under Alternative 2 as compared to the No Action Alternative over long-term average conditions and in dry and critical dry years, as summarized in Tables 11-11 and 11-12.

Table 11-11. Changes in Sacramento Valley Irrigated Acreage over the Long-term Average Conditions Under Alternative 2 as Compared to the No Action Alternative

Crops	Alternative 2 (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.
Totals may not sum due to rounding.

Table 11-12. Changes in Sacramento Valley Irrigated Acreage in Dry and Critical Dry Years Under Alternative 2 as Compared to the No Action Alternative

Crops	Alternative 2 (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
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.
Totals may not sum due to rounding.

Agricultural production in the Sacramento Valley would be similar (less than 1 percent change) under Alternative 2 as compared to the No Action Alternative over long-term average conditions and in dry and critical dry years, as summarized in Tables 11-13 and 11-14.

Table 11-13. Changes in Sacramento Valley Agricultural Production over the Long-term Average Conditions Under Alternative 2 as Compared to the No Action Alternative

Crops	Alternative 2 ($ millions)	No Action Alternative ($ millions)	Changes ($ millions)
Grain Crops	158	158	0.0
Rice	1,178	1,178	0.0
Field Crops	82	82	0.0
Forage Crops	260	260	0.0
Vegetables and Truck Crops	1,023	1,023	0.0
Orchards and Vineyards	3,375	3,375	0.0
Total	6,076	6,076	0.0

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.
All values of production are in 2016 dollar equivalent values.
Totals may not sum due to rounding.

Table 11-14. Changes in Sacramento Valley Agricultural Production in Dry and Critical Dry Years Under Alternative 2 as Compared to the No Action Alternative

Crops	Alternative 2 ($ millions)	No Action Alternative ($ millions)	Changes ($ millions)
Grain Crops	158	158	0.0
Rice	1,170	1,170	0.0
Field Crops	82	82	0.0
Forage Crops	257	257	0.0
Vegetables and Truck Crops	1,022	1,022	0.0
Orchards and Vineyards	3,375	3,375	0.0
Total	6,064	6,064	0.0

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.
All values of production are in 2016 dollar equivalent values.
Totals may not sum due to rounding.

Potential Changes in Irrigated Agricultural Production in the San Joaquin Valley Results of the SWAP analysis indicated that irrigated acreage in the San Joaquin Valley would be similar (less than 1 percent change) under Alternative 2 as compared to the No Action Alternative over long-term average conditions and in dry and critical dry years, as summarized in Tables 11-15 and 11-16.

Table 11-15. Changes in San Joaquin Valley Irrigated Acreage over the Long-term Average Conditions Under Alternative 2 as Compared to the No Action Alternative

Crops	Alternative 2 (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.
Totals may not sum due to rounding.

Table 11-16. Changes in San Joaquin Valley Irrigated Acreage in Dry and Critical Dry Years Under Alternative 2 as Compared to the No Action Alternative

Crops	Alternative 2 (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	735	735	0
Vegetables and Truck Crops	633	633	0
Orchards and Vineyards	2,154	2,154	0
Total	5,376	5,376	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.
Totals may not sum due to rounding.

Agricultural production in the San Joaquin Valley would be similar under Alternative 2 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 11-17 and 11-18.

Table 11-17. Changes in San Joaquin Valley Agricultural Production over the Long-term Average Conditions Under Alternative 2 as Compared to the No Action Alternative

Crops	Alternative 2 ($ millions)	No Action Alternative ($ millions)	Changes ($ millions)
Grain Crops	1,452	1,452	0.0
Rice	33	33	0.0
Field Crops	1,519	1,519	0.0
Forage Crops	1,508	1,508	0.0
Vegetables and Truck Crops	4,889	4,889	0.0
Orchards and Vineyards	17,499	17,499	0.0
Total	26,900	26,900	0.0

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.
All values of production are in 2016 dollar equivalent values.
Totals may not sum due to rounding.

Table 11-18. Changes in San Joaquin Valley Agricultural Production in Dry and Critical Dry Years Under Alternative 2 as Compared to the No Action Alternative

Crops	Alternative 2 ($ millions)	No Action Alternative ($ millions)	Changes ($ millions)
Grain Crops	1,437	1,437	0.0
Rice	33	33	0.0
Field Crops	1,518	1,518	0.0
Forage Crops	1,508	1,508	0.0
Vegetables and Truck Crops	4,888	4,888	0.0
Orchards and Vineyards	17,494	17,494	0.0
Total	26,879	26,879	0.0

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.
All values of production are in 2016 dollar equivalent values.
Totals may not sum due to rounding.

Summary of Environmental Consequences

Table 11-19 presents the results of the environmental consequences analysis for implementing the action alternatives compared to the No Action Alternative. The results of the impact analysis represent comparison of long-term changes that would occur between alternatives in 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 11-19. Comparison of Action Alternatives to No Action Alternative

Alternative	Potential Change	Consideration for Mitigation Measures
Alternative 1	Agricultural resources would be similar to the No Action Alternative. Changes in irrigated acreage and agricultural production would be less than 1% for all year types in the Sacramento and San Joaquin Valleys.	None needed
Alternative 2	Agricultural resources would be similar to the No Action Alternative. Changes in irrigated acreage and agricultural production would be less than 1% for all year types in the Sacramento and San Joaquin Valleys.	None needed

Key:
% = percent

Potential Mitigation Measures

Mitigation measures are identified, as appropriate, to avoid, minimize, rectify, reduce, eliminate, or compensate for adverse environmental effects of action alternatives, as compared to the No Action Alternative.

Changes in CVP operations under action alternatives 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.

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 Agricultural Resources is summarized in Table 11-20. The methodology for this cumulative effects analysis is described in the Cumulative Effects Technical Appendix.

Table 11-20. Summary of Cumulative Effects on Agricultural Resources of Action Alternatives as Compared to the No Action Alternative

Scenarios	Cumulative Effects of Actions
No Action Alternative with Associated Cumulative Effects Actions in Year 2030	*Conditions and Actions included in Quantitative Analyses* *(Conditions and actions incorporated into No Action Alternative modeling)* Climate change and sea-level rise, development under general plans, FERC relicensing projects, and some future projects to improve water quality or habitat are anticipated to reduce the availability of CVP water deliveries as compared to past conditions. Reductions in CVP water supply reliability may result in changes in agricultural production, including changes in irrigated acres and crop types. *Additional Identified Actions* *(Additional reasonably foreseeable projects or actions identified in Cumulative Effects Technical Appendix)* Additional reasonably foreseeable actions under this cumulative effects analysis are not anticipated to change CVP water deliveries or associated agricultural production.
Alternative 1 with Associated Cumulative Effects Actions in Year 2030	*Alternative 1 with Conditions and Actions included in Quantitative Analyses* Implementation of Alternative 1 would result in similar irrigated acreage and agricultural production as compared to the No Action Alternative. *Alternative 1 with Additional Identified Actions* The additional reasonably foreseeable actions are not anticipated to affect irrigated acreage or agricultural production.
Alternative 2 with Associated Cumulative Effects Actions in Year 2030	*Alternative 2 with Conditions and Actions included in Quantitative Analyses* Implementation of Alternative 2 would result in similar irrigated acreage and agricultural production as compared to the No Action Alternative. *Alternative 2 with Additional Identified Actions* The additional reasonably foreseeable actions are not anticipated to affect irrigated acreage or agricultural production.

Key:
CVP = Central Valley Project
FERC = Federal Energy Regulatory Commission

References

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Chapter 12
Socioeconomics

Introduction

This chapter describes socioeconomics in the study area and potential changes that could occur as a result of implementing the alternatives evaluated in this Environmental Impact Statement (EIS). Implementation of the alternatives could affect these resources by augmenting flows in the lower Klamath River, through operational changes of the Trinity River Division. These resources include: effects to recreation due to changes in reservoir storage and river flows; effects to commercial, sport, and tribal fisheries due to changes in river flows, river temperatures, and fish health; and effects to irrigated agricultural production value and employment due to changes in Central Valley Project (CVP) water supplies.

Affected Environment

This section describes socioeconomic conditions that could be potentially affected by implementation of the alternatives considered in this EIS. The socioeconomic conditions described in this chapter are related to employment, recreation, and agricultural output.

Characterization of Socioeconomic Conditions

Characterization of the socioeconomic conditions within the study area is based on publicly available data sources. The data sources used include the U.S. Bureau of Economic Analysis (BEA) and California Employment and Development Department (EDD). The data was summarized and used to compare historical and current trends of the socioeconomic conditions in the study area. Characterization of potentially affected commercial, sport, and tribal fisheries is based on Pacific Fishery Management Council (PFMC) data. Characterization of recreation opportunities in the study area is based on U.S. Forest Service (USFS) and local recreation area data.

Lower Klamath and Trinity River Region

The Lower Klamath and Trinity River Region includes the area in Trinity County along the Trinity River from Trinity Lake to the river's confluence with the Klamath River; and in Humboldt and Del Norte Counties along the lower Klamath River, from its confluence with the Trinity River to the Pacific Ocean. Tribal lands along the Trinity or lower Klamath Rivers, within the Lower Klamath and Trinity River Region, include the Hoopa Valley Indian Reservation, Yurok Indian Reservation, and Resighini Rancheria.

Trinity County includes extensive trails, lakes, and the Trinity River Scenic Byway, providing several venues for outdoor enthusiasts and travelers. The recreation and tourism industries are major contributors to Trinity County's local economy (EDD 2016a).

Humboldt County is the largest and most populous of the north coast counties and encompasses 2.3 million acres, including protected redwoods and recreation areas—80 percent of which is forestlands (Humboldt County 2016). Humboldt County is the leading timber producing county in the State (CDFA 2014). The portion of Humboldt County in the Lower Klamath and Trinity River Region evaluated in this EIS is located along the Trinity and Klamath Rivers. 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 Johnsons in the Yurok Tribe Indian Reservation (Humboldt County 2012).

Del Norte County is the northernmost county in California. The County includes Redwood National Park and other State parks making tourism a natural industry in the area (EDD 2016b). The portion of Del Norte County in the Lower Klamath and Trinity River Region evaluated in this EIS is located along the lower Klamath River. Most of this area is located within the Yurok Indian Reservation, and includes the communities of Requa and Klamath (Del Norte County 2003).

Employment

Total employment and the farm employment in 2005, 2010 and 2014 in the Lower Klamath and Trinity River Region counties are presented in Table 12-1. The Lower Klamath and Trinity River Region farm employment represents approximately 1 percent of farm employment in the State.

Table 12-1. Employment in Lower Klamath and Trinity River Region

Area	2005	2010	2014[1]
Total Employment			
Trinity County	5,040	4,710	4,810
Humboldt County	71,597	68,807	70,296
Del Norte County	11,210	10,903	10,964
STATE OF CALIFORNIA	**20,255,748**	**19,803,742**	**22,040,057**
Farm Employment[1]			
Trinity County	140	203	236
Humboldt County	1,431	1,325	1,396
Del Norte County	366	290	305
STATE OF CALIFORNIA	**244,144**	**232,545**	**243,247**

Source: BEA 2015a, 2015b
Note:
[1] Most recent data available.
[2] Farm employment includes employment numbers in forestry, fishing, and related activities.

Commercial, Sport, and Tribal Salmon Fishing

The alternatives may affect commercial, sport, and tribal fishing in the Lower Klamath and Trinity River Region. Participants in the ocean commercial fishery who could be potentially affected by the alternatives consist of small, independently owned and operated trollers. The fishery is a mixed stock fishery, that is, the commercial harvest includes salmon stocks from different rivers, including the Klamath River. The PFMC manages the salmon fishery on the basis of "weak stock management," whereby regulations are designed to protect weaker stocks, even if that means foregoing some harvest of the healthier stocks that comingle with the weaker

ones in the ocean harvest. In the ocean, Klamath River fall Chinook Salmon range from approximately Point Sur, California to Cape Falcon, Oregon (PFMC 2016).

The abundance of Klamath River fall-run Chinook Salmon routinely constrain the troll fishery in the range described above. Table 12-2 summarizes landings (poundage) in the last three decades in Crescent City and Eureka, California. Landings and value decreased from the 1980s to the 1990s. Factors contributing to this decline include more conservative management policies to protect weak stocks, and a 1993 opinion by the Department of the Interior Solicitor reserving 50 percent of Klamath-Trinity River salmon for the Yurok Tribe and Hoopa Valley Tribe. Landing reductions began occurring in Crescent City and Eureka port areas in the mid-1980s—in relation to conservation concerns for Klamath River fall Chinook Salmon—and low landings remain persistent features in those areas (PFMC 2016).

Commercial sales in Klamath River's Yurok and Hoopa Valley Reservation tribal fall gillnet fisheries occurred in 1987-1989, 1996, 1999-2004, and 2007-2015 (PFMC 2016). Average commercial catch of fall Chinook Salmon over those years was approximately 22,200 fish, most of which were taken in the estuary. In 2015 approximately 17,100 commercial fall Chinook Salmon were harvested, 44 percent more than in 2014, but 67 percent below the 52,100 fish harvested in 2013. The 82,900 fall Chinook Salmon harvested in 2012 was more than double the previous highest total of 40,147, taken in 1996. No spring Chinook Salmon commercial harvest occurred in 2014 or 2015. By comparison, 971 spring Chinook Salmon were harvested in 2013, 856 in 2012, and 33 in 2011. In addition to the commercial tribal fisheries discussed above, fish are taken in tribal fisheries each year for ceremonial and subsistence purposes.

Table 12-2. Landings of Troll-Caught Chinook Salmon (1000s of pounds dressed weight), 1976-2015, by Crescent City and Eureka Port Areas

Time period	Crescent City	Eureka
1976-1980 Average	393	1,403
1981-1985 Average	350	428
1986-1990 Average	155	405
1991-1995 Average	2	25
1996-2000 Average	2	35
2001	3	61
2002	54	108
2003	38	7
2004	308	65
2005	25	77
2006	0	0
2007	34	81
2008	0	0
2009	0	0
2010	0	4
2011	8	53
2012	5	78
2013	24	200
2014	27	110
2015	6	48

Source: PFMC 2016

Key:
PFMC = Pacific Fishery Management Council

In general, the recreational fishery has tended to have a somewhat more stable harvest level than the commercial fishery. The majority of the annual available ocean harvest is usually harvested by the commercial fishery. However, both commercial and recreational fisheries have suffered substantial declines relative to 1980s harvest levels (PFMC 2016). Recreational ocean-area salmon fishing takes place primarily in two modes: anglers fishing from privately-owned pleasure craft, and anglers employing the services of charter vessels. In general, success rates on charter vessels tend to be higher than success rates on private vessels. Small amounts of shore-based effort directed toward ocean-area salmon also occur from jetties and piers. The number of ocean recreational salmon trips in California in 2015 (81,800) continued a downward trend over the prior three years. The 2015 total was 32 percent below 2014 (120,300), 44 percent lower than in 2013 (147,300), and 45 percent lower than in 2012 (148,000). The number of salmon trips in 2015 was 85 percent lower than the prior year in Crescent City, and 49 percent lower in Eureka.

Recreation

Recreational visitation and related spending contribute to tourism-related sectors of the regional economy. Major recreational opportunities occur at Trinity Lake, Lewiston Reservoir, along the Trinity River between Lewiston Reservoir and its confluence with the Klamath River, and along the lower Klamath River.

Trinity Lake is a CVP facility on the Trinity River that is located approximately 50 miles northwest of Redding. Trinity Lake is part of the Whiskeytown-Shasta-Trinity National

Recreation Area and is part of the Shasta-Trinity National Forest. Recreational facilities and activities at Trinity Lake are administered by the USFS. When the water storage in the reservoir is at full capacity (water elevation at 2,370 feet mean sea level (msl)), Trinity Lake has a surface area of 17,222 acres with 147 miles of shoreline (USFS 2014). Table 12-3 presents Trinity Lake elevations that affect facility use, with useable boat ramp elevations that range 2,370 msl to 2,170 msl. Boating, windsurfing, and fishing primarily occur in the northern part of the lake near Trinity Center. Houseboats, motorboats, and water skiing primarily occur in the southern part of the lake.

Table 12-3. Trinity Lake Elevations that Affect Facility Use

Facility	Elevation (msl)	Effect of Drop Below Elevation
Stuart Fork Boat Ramps	2,320	Cease operation
Fairview Boat Ramp	2,310	Cease operation
Major Marinas	2,310	Must move facilities
Trinity Center Boat Ramp	2,295	Cease operation
Campgrounds	2,270	Decrease in use
Minersville Ramp	2,170	Cease operation

Source: USFWS et al. 2000
Key:
msl = mean sea level

Lewiston Reservoir is a CVP facility on the Trinity River that is located immediately downstream of the Trinity Dam. Lewiston Reservoir is part of the Whiskeytown-Shasta-Trinity National Recreation Area and part of the Shasta-Trinity National Forest. Recreational facilities and activities are administered by the USFS. When the water storage in the reservoir is at full capacity (water elevation at 1,874 feet msl), the reservoir has a surface area of 759 acres with 15 miles of shoreline (USFS 2014). The water elevation is generally stable in Lewiston Reservoir because it is used as a regulating reservoir, with releases for downstream uses.

The Trinity River flows approximately 112 miles from Lewiston Dam to the Klamath River (NCRWQCB et al. 2009) through Trinity, Humboldt, and Del Norte Counties. There are approximately 35 developed recreation sites and more than 200 access points along the Trinity River, and numerous river access sites between Lewiston Dam and Weitchpec (NCRWQCB et al. 2009; USFWS et al. 2000). Recreation occurs year-round in the Trinity River area. Water-related activities include boating, kayaking, canoeing, white-water rafting, inner tubing, fishing, swimming, wading, gold panning, camping, and picnicking (NCRWQCB et al. 2009). Trinity River recreation activity preferred flow ranges during the primary recreation season (Memorial Day to Labor Day) are presented in Table 12-4.

Table 12-4. Trinity River Recreation Activity Preferred Flow Ranges

Activity	Preferred Flow Ranges[1] (cfs)
Canoeing	200-1,500
Drift-Boat and Drift-Raft Fishing	200-1,500
White-Water (i.e., Kayaking, Canoeing and Rafting)	450-8,000
Recreational Mining	350-600
Shore Fishing	300-800
Swimming/Inner-Tubing	150-800
Wading	300-800
Campground Use Precluded	**Flow**
Steel Bridge, Douglas City	8,000 or greater
Steiner Flat, North Fork	10,000 or greater
Poker Bar	12,000 or greater

Source: USFWS et al. 2000

Note:
[1] Trinity River flows in the primary recreation season (Memorial Day to Labor Day)
Key:
cfs = cubic feet per second

The Klamath River continues for 43.5 miles from its Trinity River confluence to the Pacific Ocean (NCRWQCB et al. 2009). Near the confluence with the Pacific Ocean, the Klamath River flows through Redwood National Park. These reaches are primarily within Humboldt and Del Norte Counties. Recreation along the Klamath River downstream of the Trinity River is limited (DOI and DFG 2012). Canoeing, kayaking, and white-water boating occur along this reach. White-water rafting generally requires a minimum flow of 1,800 cubic feet per second (cfs) in this portion of the Klamath River. The Redwood National and State Parks operate Lagoon Creek near the confluence of the Klamath River and the Pacific Ocean (RNSP 2013; Del Norte County 2003). The California Coastal Trail is also located along the Klamath River near the Pacific Ocean confluence (California Coastal Trail 2016).

Central Valley and Bay-Delta Region

The Central Valley and Bay-Delta Region extends from above Shasta Lake south to the Tehachapi Mountains, and includes the Sacramento Valley and San Joaquin Valley.

Sacramento Valley

The Sacramento Valley includes 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 operations, and are not discussed here, including: Alpine, Sierra, Lassen, and Amador Counties.

The Sacramento Valley includes major agricultural counties, including Glenn, Colusa, Sutter and Placer Counties, as described in Chapter 11, “Agricultural Resources.” The region also includes some of the leading major timber producing counties of the State. Shasta County is the second, and Plumas County is the fifth, among the leading timber producing counties in California.

Employment Total employment and farm employment in 2005, 2010, and 2014 in the Sacramento Valley counties are presented in Table 12-5. The farm employment numbers presented in Table 12-5 include only workers directly involved in farming, forestry, and fishing activities. However, farming is one of the most important basic industries in the Central Valley

and Bay-Delta Region; and supports many other businesses including farm inputs (e.g., fertilizer, seed, machinery, and fuel) and the processing of food and fiber grown on farms.

Table 12-5. Employment in Central Valley and Bay-Delta Region – Sacramento Valley

Area	2005	2010	2014[1]
Total Employment			
Shasta County	93,546	85,727	90,076
Plumas County	11,335	9,706	9,440
Tehama County	24,692	22,497	23,814
Glenn County	11,699	11,923	12,555
Colusa County	10,589	11,506	11,787
Butte County	106,671	99,642	109,017
Yuba County	26,700	25,398	28,069
Nevada County	57,605	54,665	57,307
Sutter County	42,211	42,507	45,193
Placer County	187,268	180,749	202,549
El Dorado County	93,003	89,194	94,477
Sacramento County	793,925	761,002	830,627
Yolo County	118,799	115,917	124,228
Solano County	174,067	168,460	177,011
STATE OF CALIFORNIA	**20,255,748**	**19,803,742**	**22,040,057**
Farm Employment[2]			
Shasta County	1,726	1,751	1,935
Plumas County	171	130	126
Tehama County	2,278	2,414	2,475
Glenn County	1,787	2,143	2,295
Colusa County	1,998	1,931	2,104
Butte County	3,167	3,390	3,566
Yuba County	1,423	1,258	1,150
Nevada County	623	680	683
Sutter County	2,947	3,056	3,229
Placer County	1,578	1,476	1,424
El Dorado County	1,315	1,363	1,355
Sacramento County	2,890	2,704	2,810
Yolo County	2,385	2,914	2,967
Solano County	1,825	1,594	1,881
STATE OF CALIFORNIA	**244,144**	**232,545**	**243,247**

Source: BEA 2015a, 2015b

Note:
[1]Most recent data available.
[2]Farm employment includes employment numbers in forestry, fishing, and related activities.

Recreation CVP and State Water Project (SWP) facilities include multiple dams, reservoirs, and canals that provide substantial water-based recreational activities. Releases from dams, on major tributaries to the Sacramento River, provide numerous recreational opportunities, especially boating and fishing. Reservoirs such as Shasta Lake, Whiskeytown Lake, Folsom Lake and Lake Oroville provide boating, fishing, camping, and other recreational activities. Recreational visitation and spending contribute to tourism-related sectors of the regional economy.

San Joaquin Valley

The San Joaquin Valley includes Stanislaus, Merced, Madera, Fresno, Kings, Tulare, Kern, and San Joaquin Counties. Other counties in the San Joaquin Valley are not anticipated to be affected by changes in CVP operations, and are not discussed further.

Employment Total employment and farm employment in 2005, 2010 and 2014 in the San Joaquin Valley portion of the Central Valley and Bay-Delta Region are presented in Table 12-6. The contribution of farm employment to the total employment declined between 2005 and 2014 except in Madera and Kern Counties.

Table 12-6. Employment in Central Valley and Bay-Delta Region – San Joaquin Valley

Area	2005	2010	2014[1]
Total Employment			
Stanislaus County	222,238	209,191	227,971
Madera County	58,244	57,226	63,296
Merced County	88,256	90,679	100,466
Fresno County	428,516	425,816	468,804
Tulare County	179,581	186,016	195,901
Kings County	55,661	54,991	58,482
Kern County	345,020	353,907	412,183
San Joaquin County	282,627	268,849	294,674
STATE OF CALIFORNIA	**20,255,748**	**19,803,742**	**22,040,057**
Farm Employment[2]			
Stanislaus County	10,188	9,656	10,403
Madera County	5,264	5,205	5,766
Merced County	8,260	8,319	9,326
Fresno County	22,066	20,031	20,202
Tulare County	17,143	16,230	15,062
Kings County	4,606	4,213	4,436
Kern County	16,593	16,688	18,463
San Joaquin County	10,478	9,696	10,418
STATE OF CALIFORNIA	**244,144**	**232,545**	**243,247**

Source: BEA 2015a, 2015b

Note:

[1] Most recent data available.

[2] Farm employment includes employment numbers in forestry, fishing, and related activities.

The farm employment numbers presented in Table 12-6 include only workers directly involved in farming, forestry, and fishing activities. However, farming is one of the most important basic industries in the Central Valley; and supports many other businesses including farm inputs (e.g., fertilizer, seed, machinery, and fuel) and the processing of food and fiber grown on farms. As a result, employment both directly on farm, and indirectly dependent on farming, is higher than the values displayed in Table 12-6.

Total farm-dependent employment is not reported in the BEA or by the U.S. Bureau of Labor Statistics (BLS); however, the employment values can be estimated by studies of local economies. A study of the local economy in four counties of the San Joaquin Valley found that, for every on-farm job, about two and one-half additional jobs are supported because of inputs purchased for farming operations (NEA 1997). This estimate includes the associated effects of

workers on those farms and businesses spending their incomes on other purchases; however, the estimated values do not include employment in the processing sector. Another study indicated that the employment multiplier of the agricultural production and processing industry is 1.92, or that for every 100 agricultural production and processing jobs in the San Joaquin Valley, 92 other jobs were created in the region (UCAIC 2009).

Recreation CVP and SWP facilities include multiple dams, reservoirs, and canals that provide substantial water-based recreational activities. Releases from dams on major tributaries to the San Joaquin River provide numerous recreational opportunities. Reservoirs such as the San Luis and New Melones Reservoirs provide boating, fishing, camping, and other recreational activities. Recreational visitation and spending contribute to tourism-related sectors of the regional economy.

Impact Analysis

Potential Mechanisms for Change in Socioeconomics and Analytical Methods

The impact assessment considers changes in socioeconomic factors related to changes in CVP operations, under the alternatives as compared to the No Action Alternative. More detailed discussions of changes in agricultural production are presented in Chapter 11, “Agricultural Resources.”

Flow augmentation actions, under the actions alternatives as compared to the No Action Alternative, could change conditions for salmon in the lower Klamath and Trinity Rivers that are relied upon by commercial, sport, and tribal fisherman; water supply availability for CVP and SWP water users; and, recreational opportunities at reservoirs that store CVP and SWP water and in rivers downstream of these facilities.

Changes in Commercial, Sport, and Tribal Salmon Fishing Opportunities

Flow augmentation under the action alternatives could change the salmon population as compared to the No Action Alternative. The action alternatives include flow augmentation actions to reduce the likelihood, and potentially reduce the severity, of an *Ichthyophthirius multifiliis* (Ich) epizootic event in the lower Klamath and Trinity Rivers that could lead to an associated fish die-off in future years. Commercial, sport, and tribal fishing primarily rely upon fall-run Chinook Salmon because the populations of other runs of salmon are substantially lower. Specific population changes for fall-run Chinook Salmon are not projected in this EIS. Therefore, this chapter presents a qualitative analysis of potential changes in socioeconomic factors, under the alternatives as compared to the No Action Alternative.

Regional Changes in Irrigated Agricultural Production Value and Employment

Changes in CVP operations could change the extent of total agricultural production value as compared to the No Action Alternative. This analysis uses model output from the Statewide Agricultural Production (SWAP) model and the IMpact Analysis for PLANning (IMPLAN) model as described in the Analytical Tools Technical Appendix of this EIS.

As described in Chapter 11, “Agricultural Resources,” there was no change in agricultural production in the Central Valley under long-term conditions (over the 82-year model simulation

period). Therefore, this analysis only addresses regional economic changes during dry and critical years. The impact to irrigated acreage and agricultural production is relatively small under the action alternatives. Small changes in CVP irrigation supplies would be offset by small changes in groundwater pumping, with only small changes in crop acreage in production. However, this is an aggregate result for the Central Valley. Individual growers that rely on CVP supply and have no access to groundwater could have their irrigated acreage affected by larger amounts. From the larger, regional perspective, total value of agricultural production under the alternatives, as compared to the No Action Alternative, is estimated to be similar.

The regional economic analysis was conducted using the results of the impact analysis on agricultural production. The incremental impact results, estimated by the SWAP economic model, were input into the regional IMPLAN models as the direct change caused by each alternative, as compared to the No Action Alternative. Changes in economic effects depend upon changes in agricultural production, interactions within the regional economy, and "leakage" of economic activity between regions. Economic linkages create multiplier effects in a regional economy in the IMPLAN input-output model based upon estimates of county-level final demands and final payments developed from published data; national average matrix of technical coefficients; and mathematical relationships. IMPLAN uses information from the BEA, BLS, and other Federal and State government agencies. Data is collected for 440 different industrial sectors of the national economy, per the North American Industry Classification System, based on the primary commodity or service produced. Data sets are provided for the IMPLAN model for each county in the United States. In this analysis, counties were grouped into the Central Valley and Bay-Delta Region.

IMPLAN is a static model that estimates impacts for a snapshot in time when the impacts are expected to occur, based on the makeup of the economy at the time of the underlying IMPLAN data. IMPLAN measures the initial impact to the economy based on average-expenditure patterns, but does not consider long-term adjustments if labor and capital move into alternative uses.

The SWAP and IMPLAN models are annual-time step models that use information from the monthly-time step model. The model results represent long-term responses and must be used in a comparative manner to reduce the effects of the use of monthly assumptions—and other assumptions that are indicative of real-time operations but do not specifically match real-time observations. The CalSim II model output includes minor fluctuations of up to 5 percent due to model assumptions and approaches. Therefore, if the quantitative changes between a specific alternative and the No Action Alternative are 5 percent or less, the conditions under the specific alternative would be considered to be "similar" to conditions under the No Action Alternative.

Regional Changes in Municipal and Industrial Water Supplies and Water Supply Costs

Changes in CVP operations could change availability of water supplies for municipal and industrial (M&I) water in the study area, related costs of additional supplies or shortages, and changes in regional economics as compared to the No Action Alternative. M&I water supplies under the alternatives would be similar to the No Action Alternative as described in Chapter 4, "Surface Water Supply and Management." Therefore, changes in the costs of additional supplies or shortages under the alternatives, as compared to the No Action Alternative, are not anticipated and not evaluated in this EIS.

Changes in Recreational Economics

Reservoirs that store CVP and SWP water provide a wide diversity of recreational experiences on the water surface, at shoreline campgrounds, and along shoreline trails. Associated recreational visitation contributes to tourism-related sectors of local economies. By the end of September, reservoir surface-water elevations can decline from higher elevations in the spring by up to 100 feet in Shasta Lake and Lake Oroville; and over 50 feet in Trinity and Folsom Lakes and New Melones and San Luis Reservoirs. As the water elevation declines, boat ramps may become unavailable and the water surface recedes along slopes from shoreline campgrounds and trails. Changes in CVP and SWP operations under the alternatives could change the surface water elevations—especially in dry and critical years—as compared to the No Action Alternative.

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 is typically the end of the highest volume recreation-participation season, and reservoir elevations are generally low. To assess changes in recreational resources, changes in reservoir elevations and the distance-to-water surface elevation from full-capacity storage at the end of September were compared between action alternatives and the No Action Alternative. The recreation season (May through September) end of month reservoir elevations were compared to Trinity Lake elevations that affect facility use displayed in Table 12-3, above, as a measure of facility availability. The number of months in which Trinity Lake elevations affect facility use and a percentage of recreation facility availability was developed and compared to the No Action Alternative. Changes in CVP water supplies and operations, under alternatives as compared to the No Action Alternative, would result in similar reservoir elevations in the Central Valley and Bay-Delta Region in all water year types, as described in Chapter 4, “Surface Water Supply and Management.” Therefore, this analysis only addresses regional reservoir recreational-opportunity changes in the Lower Klamath and Trinity River Region.

Changes in CVP operations under the alternatives could change the river flows in a manner that would affect recreational opportunities, including boating and swimming during the spring and summer months, especially in dry and critical years. Results of the CalSim II and Trinity River HEC-5Q Water Quality models were used to assess changes in daily flows that could affect recreational opportunities under the alternatives, as compared to the No Action Alternative. Changes in CVP water supplies and operations under alternatives as compared to the No Action Alternative in the Central Valley and Bay-Delta Region would result in a range of river flows within the historical operational range and recreational opportunities are not anticipated to change. Therefore, this analysis only addresses regional river recreational-opportunity changes in the Lower Klamath and Trinity River Region. Changes in daily flows were used to compare the percentage of flows in the primary recreation season with the preferred range of flows for Trinity River recreation activities (presented in Table 12-4, above)—between the alternatives and the No Action Alternative—to assess changes in recreational opportunities. This EIS does not quantitatively analyze potential changes in recreation user days or recreation spending. The qualitative analysis presented in this chapter is based upon changes in recreational opportunities related to changes under the alternatives as compared to the No Action Alternative.

Evaluation of Alternatives

The impact analysis in this EIS is based upon the comparison of the alternatives to the No Action Alternative projected in the year 2030.

No Action Alternative

Under the No Action Alternative, socioeconomic resources would be similar to the conditions described in the *Affected Environment* section of this chapter. Conditions in 2030 would be different than existing conditions primarily due to climate change and sea-level rise, general plan development throughout California, and implementation of reasonable and foreseeable water resource management projects to provide water supplies. Climate change and sea-level rise are anticipated to reduce long-term average CVP water supply deliveries by 2030, as compared to recent historical long-term average deliveries. These reduced deliveries could result in more crop idling or changes in cropping patterns, and changes in regional income and employment. The No Action Alternative assumes implementation of a number of conservation efforts and major water supply projects by 2030 that would provide additional water supply flexibility and availability.

Under the No Action Alternative, climate change and sea-level rise, and development under the general plans, are anticipated to reduce carryover storage in reservoirs. It would reduce CVP and SWP water supply availability and recreational opportunities at some reservoirs that store CVP and SWP water, and in the rivers where dams make releases.

Under the No Action Alternative, the flows in the lower Klamath River are anticipated to fall under 2,800 cfs during late August and September in most years. These conditions, combined with the potential of Ich presence in the river, lead to an increased risk for a fish die-off in the lower Klamath River under the No Action Alternative. Fish die-offs would negatively impact any fishery-related socioeconomic resources. This includes lost revenue from commercial salmon sales, loss of fishing guide and charter revenue (both on the river and in the ocean), decreased recreational fishing tourism, and the added cost to people who rely on salmon for food who would then need to purchase other food sources.

Proposed Action (Alternative 1)

Lower Klamath and Trinity River Region

Regional Changes to Commercial, Sport, and Tribal Salmon Fishing Trinity River flows would be increased through supplemental flows to prevent a disease outbreak in the lower Klamath River in years when the flow in the lower Klamath River is projected to be low (less than 2,800 cfs, under Alternative 1 as compared to the No Action Alternative. Flow augmentation under Alternative 1 would increase cross-sectional channel area to expand habitat space, increase water velocities that can reduce efficacy of Ich parasites from finding and attaching to adult salmon hosts, potentially provide migration cues to further disperse adult salmon and reduce densities and reduce the frequency of water temperatures exceeding 73.4 degrees Fahrenheit (°F). These conditions would be expected to result in reduced risk of Ich infection, epizootic outbreaks and consequent fish die-offs. This could result in improved commercial salmon sales, fishing guide and charter revenue (both on the river and in the ocean), recreational fishing tourism, and the reduction in cost to the people who rely on the salmon for food.

Regional Changes in Recreational Opportunities As described in Chapter 4, “Surface Water Supply and Management,” Trinity Lake elevations under Alternative 1 are similar to the No

Action Alternative, with 1 percent or less change in all months of all water year types. The end of September distance-to-water surface elevation from full-capacity storage would be increased (less than 5 percent) for all water year types. Table 12-7 presents changes in Trinity Lake recreation facility availability. Trinity Lake recreation facility availability would change by less than 1 percent for all facilities. Changes to water surface and shoreline activity, and reservoir-recreational economic opportunities under Alternative 1 are not anticipated due to these small changes. Similarly, changes in Trinity Lake recreational visitation and spending in tourism-related sectors are not anticipated.

Table 12-7. Changes in Percentage of Trinity Lake Recreation Facility Availability Under Alternative 1 as Compared to the No Action Alternative

Facility	Elevation (msl)	No Action (percent availability)	Alternative 1 (percent availability)	Percent Change[1]
Stuart Fork Boat Ramps	2,320	44	43	0
Fairview Boat Ramp	2,310	51	50	0
Major Marinas	2,310	51	50	0
Trinity Center Boat Ramp	2,295	59	59	0
Campgrounds	2,270	75	74	-1
Minersville Ramp	2,170	98	98	0

Note:
[1] Percent change may not sum due to rounding. Changes in Trinity Lake recreation facility availability are estimated for the recreation season.
Key:
msl = mean sea level

As described in Chapter 4, “Surface Water Supply and Management,” flows in the Trinity River, released from Lewiston Dam, would increase in August and September of all year types, from 2 percent in August of extremely wet years, to 115 percent in September of critically dry years (under Alternative 1 as compared to the No Action Alternative). Table 12-8 presents changes in the percentage of flows in the preferred range for Trinity River recreation activities. Under Alternative 1, the percentage of flows released from Lewiston Dam in the primary recreation season in the preferred flow range for canoeing, drift-boating, and drift-raft fishing would decrease by less than 1 percent. The percentage of flows released from Lewiston Dam in the preferred range for white-water activities (i.e., kayaking and rafting) would be the same. The percentage of flows in the preferred range for recreational mining would decrease 6 percent. The percentage of flows in the preferred range for shore fishing, swimming, inner tubing, and wading would decrease by 4 percent. In addition, the percentage of flows that would preclude campground use (presented in Table 12-4 above) would not change during the primary recreation season at Poker Bar, Steiner Flat, North Fork, Steel Bridge, and Douglas City Campgrounds.

Table 12-8. Changes in Percentage of Trinity River Flows in Preferred Range for Recreation Activities Under Alternative 1 as Compared to the No Action Alternative

Recreation Activity	Preferred Flow Ranges[1] (cfs)	No Action Alternative (percent)	Alternative 1 (percent)	Change (percent)
Canoeing	200-1,500	71	70	-1
Drift-Boat and Drift-Raft Fishing	200-1,500	71	70	-1
White Water (i.e., Kayaking and Rafting)	450-8,000	97	97	0
Recreational Mining	350-600	58	52	-6
Shore Fishing	300-800	61	57	-4
Swimming/Inner-Tubing	150-800	61	57	-4
Wading	300-800	61	57	-4

Note:
[1] Trinity River flows in the primary recreation season (Memorial Day to Labor Day)

The percentage of flows released from Lewiston Dam in the preferred range for whitewater activities would not change. However, white-water participants who prefer flows above the minimum of the preferred range would experience improved conditions compared to the No Action Alternative. The small change in percentages of flows in the preferred range for canoeing, drift-boat and drift-raft fishing, recreational mining, shore fishing, swimming, inner tubing, and wading in the Trinity River are not anticipated to change recreational visitation and spending. Overall, under Alternative 1, recreational visitation and spending is anticipated to be similar during the primary recreation season.

In the lower Klamath River, from the Trinity River confluence to the Pacific Ocean, limited recreation opportunities exist. Recreational opportunities within the lower Klamath River are anticipated to be similar.

Central Valley and Bay-Delta Region

Regional Changes to Irrigated Agriculture As described in Chapter 4, "Surface Water Supply and Management," CVP and SWP agricultural water deliveries under long-term average conditions would be similar under Alternative 1 as compared to the No Action. In dry and critical water year types CVP North-of-Delta (NOD) agricultural water contractor deliveries would be reduced by 1 percent and CVP South-of-Delta (SOD) agricultural contractor deliveries would be reduced by 1 percent. It is anticipated that groundwater use would be similar; and sustainable groundwater management plans would not be fully implemented until the 2040s, as discussed in Chapter 11, "Agricultural Resources."

Agricultural production value under long-term average conditions would not change. Agricultural production value in Sacramento and San Joaquin Valleys under dry and critical dry conditions would be similar and decrease by less than 1 percent. The direct changes in agricultural production in dry and critical years would result in small changes to employment and regional economic output in the Sacramento and San Joaquin Valleys, as summarized in Tables 12-9 and 12-10, respectively. In the Sacramento Valley, the small decrease in agricultural production would lead to small decreases in related indirect and induced economic output and employment (less than 1 percent change). In the San Joaquin Valley, agricultural production value and employment would be similar (less than 1 percent change).

Table 12-9. Changes in Agricultural-Related Employment and Regional Economic Output for the Sacramento Valley Under Alternative 1 as Compared to the No Action Alternative in Dry and Critical Years

Economic Sectors	Direct	Indirect	Induced	Total
Employment (Jobs)				
Agriculture	-14	-3	0	-17
Mining and Logging	0	0	0	0
Construction	0	0	0	0
Manufacturing	0	0	0	0
Transportation, Warehousing and Utilities	0	0	0	0
Wholesale Trade	0	0	0	0
Retail Trade	0	0	-1	-1
Information	0	0	0	0
Financial Activities	0	0	0	-1
Services	0	-2	-3	-4
Government	0	0	0	0
Total	**-14**	**-5**	**-4**	**-24**
Economic Output ($ millions)				
Agriculture	-1.5	-0.1	0.0	-1.6
Mining and Logging	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0
Manufacturing	0.0	0.0	0.0	0.0
Transportation, Warehousing and Utilities	0.0	0.0	0.0	0.0
Wholesale Trade	0.0	0.0	-0.1	-0.1
Retail Trade	0.0	-0.1	0.0	-0.1
Information	0.0	0.0	0.0	0.0
Financial Activities	0.0	-0.1	-0.1	-0.1
Services	0.0	-0.2	-0.3	-0.5
Government	0.0	0.0	0.0	0.0
Total	**-1.5**	**-0.6**	**-0.5**	**-2.6**

Notes:
Employment and economic output changes estimated by the Impact Analysis for Planning model.
Economic output is in 2016 dollars. Totals may not sum due to rounding.

Table 12-10. Changes in Agricultural-Related Employment and Regional Economic Output for the San Joaquin Valley Under Alternative 1 as Compared to the No Action Alternative in Dry and Critical Dry Years

Economic Sectors	Direct	Indirect	Induced	Total
Employment (Jobs)				
Agriculture	1	0	0	1
Mining and Logging	0	0	0	0
Construction	0	0	0	0
Manufacturing	0	0	0	0
Transportation, Warehousing and Utilities	0	0	0	0
Wholesale Trade	0	0	-1	-1
Retail Trade	0	0	0	0
Information	0	0	0	0
Financial Activities	0	0	0	0
Services	0	0	-2	-2
Government	0	0	0	0
Total	**1**	**1**	**-4**	**-2**
Economic Output ($ millions)				
Agriculture	0.1	0.0	0.0	0.1
Mining and Logging	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0
Manufacturing	0.0	0.0	0.0	0.0
Transportation, Warehousing and Utilities	0.0	0.0	0.0	0.0
Wholesale Trade	0.0	0.0	-0.1	-0.1
Retail Trade	0.0	0.0	0.0	0.0
Information	0.0	0.0	0.0	0.0
Financial Activities	0.0	0.0	0.0	0.0
Services	0.0	0.0	-0.3	-0.3
Government	0.0	0.0	0.0	0.0
Total	**0.1**	**0.0**	**-0.4**	**-0.3**

Notes:
Employment and economic output changes estimated by the Impact Analysis for Planning model. Economic output is in 2016 dollars. Totals may not sum due to rounding.

Trinity River Record of Decision Flow Rescheduling Alternative (Alternative 2)

Lower Klamath and Trinity River Region

Regional Changes to Commercial, Sport, and Tribal Salmon Fishing Trinity River flows would be increased through supplemental flows, to prevent a disease outbreak in the lower Klamath River in years when the flow in the lower Klamath River are projected to be low (less than 2,800 cfs, under Alternative 2 as compared to the No Action Alternative. Flow augmentation under Alternative 2 would increase cross-sectional channel area to expand habitat space, increase water velocities that can reduce efficacy of Ich parasites from finding and attaching to adult salmon hosts, potentially provide migration cues to further disperse adult salmon and reduce densities and reduce the frequency of water temperatures exceeding 73.4°F. These conditions would be expected to result in reduced risk of Ich infection, epizootic outbreaks and consequent fish die-offs. This could result in improved commercial salmon sales, fishing guide and charter revenue (both on the river and in the ocean), recreational fishing tourism, and the reduction in cost to the people who rely on the salmon for food.

Regional Changes to Irrigated Agriculture There are no agricultural lands irrigated with CVP water supplies in the Lower Klamath and Trinity River Region. Therefore, there would be no changes in irrigated lands under Alternative 2 as compared to the No Action Alternative.

Regional Changes in Recreational Opportunities Trinity Lake elevations under Alternative 2 are similar to those under the No Action Alternative, with less than 1 percent change in all months of all water year type. The end of September distance-to-water surface elevation from full-capacity storage would be increased (less than 1 percent) in any water year type. Table 12-11 presents changes in Trinity Lake recreation facility availability. Trinity Lake recreation facility availability would change by less than 1 percent for all facilities. Changes to water surface and shoreline activity, and reservoir-recreational economic opportunities under Alternative 2 are not anticipated. Changes in recreational visitation and spending in tourism-related sectors are not anticipated.

Table 12-11. Changes in Trinity Lake Recreation Facility Availability Under Alternative 2 as Compared to the No Action Alternative

Facility	Elevation (msl)	No Action (percent availability)	Alternative 2 (percent availability)	Percent Change[1]
Stuart Fork Boat Ramps	2,320	44	43	0
Fairview Boat Ramp	2,310	51	51	0
Major Marinas	2,310	51	51	0
Trinity Center Boat Ramp	2,295	59	60	1
Campgrounds	2,270	75	75	1
Minersville Ramp	2,170	98	98	0

Note:
[1] Percent change may not sum due to rounding. Changes in Trinity Lake recreation facility availability are estimated for the recreation season.
Key:
msl = mean sea level

Flows in the Trinity River released from Lewiston Dam would increase in August and September of all water year type, from 2 percent in August of extremely wet years to 132 percent in September of critically dry years, under Alternative 2 as compared to the No Action Alternative. Decreases in flows in May and June of most water year type, from 1 percent in June of extremely wet years to 38 percent in June of critically dry years, would occur under Alternative 2 as compared to the No Action Alternative.

Table 12-12 presents changes in the percentage of flows in the preferred range for Trinity River recreation activities. Under Alternative 2, the percentage of flows released from Lewiston Dam—during the primary recreation season in the preferred-flow range for canoeing, drift-boating, and drift-raft fishing—would not change. The percentage of flows released from Lewiston Dam in the preferred range for white-water activities (i.e., kayaking and rafting) would increase 1 percent. The percentage of flows in the preferred range for recreational mining would decrease 3 percent. The percentage of flows in the preferred range for shore fishing, swimming, inner tubing, and wading would decrease by 1 percent or less. In addition, the percentage of flows that would preclude campground use (presented in Table 12-4 above) would not change

during the primary recreation season at Poker Bar, Steiner Flat, North Fork, Steel Bridge, and Douglas City Campgrounds.

Table 12-12. Changes in Percentage of Trinity River Flows in Preferred Range for Recreation Activities Under Alternative 2 as Compared to the No Action Alternative

Recreation Activity	Preferred Flow Ranges[1] (cfs)	No Action Alternative (percent)	Alternative 2 (percent)	Change (percent)
Canoeing	200-1,500	71	70	0
Drift-Boat and Drift-Raft Fishing	200-1,500	71	70	0
White Water (i.e., Kayaking and Rafting)	450-8,000	97	98	1
Recreational Mining	350-600	58	54	-3
Shore Fishing	300-800	61	60	-1
Swimming/Inner-Tubing	150-800	61	60	-1
Wading	300-800	61	60	-1

Note:
[1] Trinity River flows in the primary recreation season (Memorial Day to Labor Day)

The small change in percentage of flows released from Lewiston Dam in the preferred range for white-water recreational visitation is not anticipated to increase white-water recreational visitation and spending. However, white-water participants who prefer flows above the minimum of the preferred range would experience improved conditions compared to the No Action Alternative. The small change in percentages of flows in the preferred range for recreational mining, shore fishing, swimming, inner tubing, and wading in the Trinity River are not anticipated to change recreational visitation and spending. Overall, under Alternative 2 Trinity River recreational visitation and spending are anticipated to be similar during the primary recreation.

In the lower Klamath River, from the Trinity River confluence to the Pacific Ocean, limited recreation opportunities exist. Recreational opportunities within the lower Klamath River are anticipated to be similar.

Central Valley and Bay-Delta Region

Regional Changes to Irrigated Agriculture CVP and SWP water supplies would be similar under Alternative 1 as compared to the No Action Alternative under long-term average conditions. In dry and critical water year types CVP NOD agricultural water contractor deliveries would be reduced by less than 1 percent. In dry water year type conditions CVP SOD agricultural contractor deliveries would be increased by less than 1 percent and in critical water year type conditions would be reduced by less than 1 percent. It is anticipated that groundwater use would be similar; and sustainable groundwater management plans would not be fully implemented until the 2040s, as discussed in Chapter 11, “Agricultural Resources.”

Agricultural production value under long-term average, and dry and critical year conditions would not change. Employment and regional economic output in the Sacramento and San Joaquin Valleys would also not change, as summarized in Tables 12-13 and 12-14, respectively.

Table 12-13. Changes in Agricultural-Related Employment and Regional Economic Output for the Sacramento Valley Under Alternative 2 as Compared to the No Action Alternative in Dry and Critical Years

Economic Sectors	Direct	Indirect	Induced	Total
Employment (Jobs)				
Agriculture	0	0	0	0
Mining and Logging	0	0	0	0
Construction	0	0	0	0
Manufacturing	0	0	0	0
Transportation, Warehousing and Utilities	0	0	0	0
Wholesale Trade	0	0	0	0
Retail Trade	0	0	0	0
Information	0	0	0	0
Financial Activities	0	0	0	0
Services	0	0	0	0
Government	0	0	0	0
Total	**0**	**0**	**0**	**0**
Economic Output ($ millions)				
Agriculture	0.0	0.0	0.0	0.0
Mining and Logging	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0
Manufacturing	0.0	0.0	0.0	0.0
Transportation, Warehousing and Utilities	0.0	0.0	0.0	0.0
Wholesale Trade	0.0	0.0	0.0	0.0
Retail Trade	0.0	0.0	0.0	0.0
Information	0.0	0.0	0.0	0.0
Financial Activities	0.0	0.0	0.0	0.0
Services	0.0	0.0	0.0	0.0
Government	0.0	0.0	0.0	0.0
Total	**0.0**	**0.0**	**0.0**	**0.0**

Notes:
Employment and economic output changes estimated by the Impact Analysis for Planning model. Economic output is in 2016 dollars. Totals may not sum due to rounding.

Table 12-14. Changes in Agricultural-Related Employment and Regional Economic Output for the San Joaquin Valley Under Alternative 2 as Compared to the No Action Alternative in Dry and Critical Years

Economic Sectors	Direct	Indirect	Induced	Total
Employment (Jobs)				
Agriculture	0	0	0	0
Mining and Logging	0	0	0	0
Construction	0	0	0	0
Manufacturing	0	0	0	0
Transportation, Warehousing and Utilities	0	0	0	0
Wholesale Trade	0	0	0	0
Retail Trade	0	0	0	0
Information	0	0	0	0
Financial Activities	0	0	0	0
Services	0	0	0	0
Government	0	0	0	0
Total	**0**	**0**	**0**	**0**
Economic Output ($ millions)				
Agriculture	0.0	0.0	0.0	0.0
Mining and Logging	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0
Manufacturing	0.0	0.0	0.0	0.0
Transportation, Warehousing and Utilities	0.0	0.0	0.0	0.0
Wholesale Trade	0.0	0.0	0.0	0.0
Retail Trade	0.0	0.0	0.0	0.0
Information	0.0	0.0	0.0	0.0
Financial Activities	0.0	0.0	0.0	0.0
Services	0.0	0.0	0.0	0.0
Government	0.0	0.0	0.0	0.0
Total	**0.0**	**0.0**	**0.0**	**0.0**

Notes:
Employment and economic output changes estimated by the Impact Analysis for Planning model. Economic output is in 2016 dollars. Totals may not sum due to rounding.

Summary of Environmental Consequences

Table 12-15 presents the results of the environmental consequences analysis for implementing the action alternatives compared to the No Action Alternative.

Potential Mitigation Measures

Mitigation measures are identified, as appropriate, to avoid, minimize, rectify, reduce, eliminate, or compensate for adverse environmental effects of action alternatives, as compared to the No Action Alternative.

By augmenting flows in the lower Klamath River, and associated changes in CVP and SWP operations, action alternatives—as compared to the No Action Alternative—would not result in adverse changes in socioeconomic factors related to regional salmon fishing, agricultural production, M&I water supply operating expenses, and recreational resources. Therefore, there would be no adverse impacts to socioeconomic resources; and no mitigation measures are required.

Table 12-15. Comparison of Action Alternatives to No Action Alternative

Alternative	Potential Change	Consideration for Mitigation Measures
Alternative 1	*Lower Klamath and Trinity Rivers* Commercial, sport, and tribal fishing opportunities would be improved due to reduced likelihood of an Ich outbreak and associated fish-die off. Recreational economic factors would be similar, related to the use of Trinity Lake. Recreational economic factors would be similar, related to the use of rivers downstream of Lewiston Dam. *Central Valley and Bay-Delta* Agricultural production related employment would decrease by less than 1 percent and be similar. Recreational economic factors would be similar related to the use of CVP reservoirs.	None needed
Alternative 2	*Lower Klamath and Trinity Rivers* Commercial, sport, and tribal fishing opportunities would be improved due to reduced likelihood of an Ich outbreak and associated fish-die off. Recreational economic factors would be similar, related to the use of Trinity Lake. Recreational economic factors would be similar, related to the use of rivers downstream of Lewiston Dam. *Central Valley and Bay-Delta* Agricultural production related employment would be similar. Recreational economic factors would be similar related to the use of CVP reservoirs.	None needed

Key:
CVP = Central Valley Project

Cumulative Effects Analysis

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 agricultural resources is summarized in Table 12-16. The methodology for this cumulative effects analysis is described in the Cumulative Effects Technical Appendix.

Table 12-16. Summary of Cumulative Effects on Socioeconomics of Action Alternatives as Compared to the No Action Alternative

Scenarios	Cumulative Effects of Actions
No Action Alternative with Associated Cumulative Effects Actions Projected for Year 2030	*Conditions and Actions included in Quantitative Analyses* *(Conditions and actions incorporated into No Action Alternative modeling)* *Commercial, Sport and Tribal Fishing in the Klamath* Climate change is anticipated to shift winter precipitation from snow to rain, which will lead to larger runoff events in the winter and less snowmelt in the spring. River flows in turn will be reduced during summer months. Lower summer river flows, combined with increases in ambient air temperatures, are expected to cause further increases in water temperatures compared to recent historical conditions. Lower flow and increased temperature conditions during summer months would likely increase the potential for Ich epizootic events and related fish die-offs. *Agricultural Water-Related Employment* Climate change and sea-level rise, development under general plans, FERC relicensing projects, and some future projects to improve water quality or habitat are anticipated to reduce the availability of CVP water supplies as compared to past conditions. Reductions in CVP water supply reliability may change agricultural water-related employment. *Recreation* Climate change and sea level rise, and development under the general plans, are anticipated to reduce carryover storage in reservoirs and change instream flow patterns in a manner that would change recreational opportunities and associated recreation economic factors. *Additional Identified Actions* *(Additional reasonably foreseeable projects or actions identified in Cumulative Effects Technical Appendix)* *Commercial, Sport and Tribal Fishing in the Klamath Basin* Additional reasonably foreseeable actions, including the Klamath River Main Stem Dam Removal and Hoopa Valley Tribe Watershed Restoration Projects, are anticipated to improve and increase fish habitat. Improved and increased fish habitat is anticipated to have beneficial effects to commercial, sport and tribal fishing. *Agricultural Water-Related Employment* Additional reasonably foreseeable actions under this cumulative effects analysis are not anticipated to change CVP water deliveries or associated agricultural water-related employment. *Recreation* Additional reasonably foreseeable actions considered under this cumulative effects analysis are not anticipated to affect recreation economic factors.
Alternative 1 with Associated Cumulative Effects Actions Projected for Year 2030	*Alternative 1 with Conditions and Actions included in Quantitative Analyses* *Commercial, Sport and Tribal Fishing in the Klamath River Basin* Implementation of Alternative 1 would result in improved commercial, sport and tribal fishing as compared to the No Action Alternative. *Agricultural Water-Related Employment* Implementation of Alternative 1 would result in similar agricultural water-related employment as compared to the No Action Alternative. *Recreation* Implementation of Alternative 1 would result in similar recreation economic factors as compared to the No Action Alternative. *Alternative 1 with Additional Identified Actions* *Commercial, Sport and Tribal Fishing in the Klamath River Basin* Alternative 1 with the additional reasonably foreseeable actions would result in beneficial effects to fish habitat in the Klamath Basin, and therefore cumulative effects to commercial, sport and tribal fishing are not anticipated. *Agricultural Water-Related Employment* The additional reasonably foreseeable actions are not anticipated to affect agricultural water-related employment *Recreation* The additional reasonably foreseeable actions are not anticipated to affect recreation economic factors.

Table 12-16. Summary of Cumulative Effects on Socioeconomics of Action Alternatives as Compared to the No Action Alternative (contd.)

Scenarios	Cumulative Effects of Actions
Alternative 2 with Associated Cumulative Effects Actions Projected for Year 2030	*Alternative 2 with Conditions and Actions included in Quantitative Analyses* *Commercial, Sport and Tribal Fishing in the Klamath River Basin* Implementation of Alternative 2 would result in improved commercial, sport and tribal fishing as compared to the No Action Alternative. *Agricultural Water-Related Employment* Implementation of Alternative 2 would result in similar agricultural water-related employment as compared to the No Action Alternative. *Recreation* Implementation of Alternative 2 would result in similar recreation economic factors as compared to the No Action Alternative. *Alternative 2 with Additional Identified Actions* *Commercial, Sport and Tribal Fishing in the Klamath River Basin* Alternative 2 with the additional reasonably foreseeable actions would result in beneficial effects to fish habitat in the Klamath Basin, and therefore cumulative effects to commercial, sport and tribal fishing are not anticipated. *Agricultural Water-Related Employment* The additional reasonably foreseeable actions are not anticipated to affect agricultural water-related employment. *Recreation* The additional reasonably foreseeable actions are not anticipated to affect recreation economic factors.

Key:
CVP = Central Valley Project
FERC = Federal Energy Regulatory Commission

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Chapter 13
Indian Trust Assets

Introduction

This chapter describes Indian Trust Assets (ITA) in the study area and potential impacts that could occur as a result of implementing the alternatives evaluated in this Environmental Impact Statement (EIS). Implementation of the alternatives could affect these resources through potential changes in operation of the Trinity River Division (TRD) of the Central Valley Project (CVP). Direct effects to ITAs caused by the implementation of the alternatives analyzed in this EIS—specifically tribal water rights, fishing rights, and rights to wildlife and vegetation resources—are related to flow changes in the Trinity River and lower Klamath River.

Regulatory Environment and Compliance Requirements

Consistent with President William J. Clinton's 1994 memorandum, "Government-to-Government Relations with Native American Tribal Governments," the U.S. Department of the Interior, Bureau of Reclamation (Reclamation) assesses the effect of its programs on tribal trust resources and federally-recognized tribal governments. Reclamation is tasked to actively engage federally-recognized tribal governments and consult with such tribes on government-to-government level when its actions affect tribal trust resources (Federal Register, Vol. 59, No. 85, May 4, 1994, pages 22951–22952). The Department of Interior (DOI) Departmental Manual Part 512.2 describes the responsibility for ensuring protection of tribal trust resources to the heads of bureaus and offices. DOI is required to carry out activities in a manner that protects tribal trust resources and avoids adverse effects whenever possible.

ITAs are legal interests in property held in trust by the U.S. Government for Federally-recognized Indian tribes or individual Indians. An Indian trust has three components: (1) the trustee, (2) the beneficiary, and (3) the trust asset. ITAs can include land, minerals, federally-reserved hunting and fishing rights, Federally-reserved water rights, and in-stream flows associated with trust land. Beneficiaries of the Indian trust relationship are Federally-recognized Indian tribes with trust land; the U.S. is the trustee. By definition, ITAs cannot be sold, leased, or otherwise encumbered without approval of the U.S. The characterization and application of the U.S. trust relationship have been defined by case law that interprets Congressional acts, executive orders, and historical treaty provisions.

The Federal government, through treaty, statute, or regulation, may take on specific, enforceable fiduciary obligations that give rise to a trust responsibility to Federally-recognized tribes and individual Indians possessing trust assets. Courts have recognized an enforceable Federal fiduciary duty with respect to Federal supervision of Indian money or natural resources, held in

trust by the Federal government, where specific treaties, statutes or regulations create such a fiduciary duty.

Affected Environment

Lower Klamath and Trinity River Region

Multiple court rulings have established the important "Indian purpose" for the Hoopa Valley Indian Reservation. In addition, the Yurok Indian Reservation is to reserve tribal rights to harvest fish from the Klamath and Trinity Rivers. The Hoopa Valley Indian Reservation is located on the Trinity River. The Yurok Indian Reservation is on the Klamath River at its confluence with the Trinity River. Numerous and varied trust assets exist in the vicinity of the action alternatives, including fish, riparian plants, and wildlife. While the Hoopa and Yurok Tribes are described here, there are also others within the region including, but not limited to, the Karuk and Klamath tribes, Resighini Rancheria, and Quartz Valley Indian Tribe, as shown in Figure 13-1.

History and Culture of Tribal Groups

This section provides an overview of the individual histories and cultures of the Hoopa Valley and Yurok Tribes in the Lower Klamath and Trinity River Region. Each tribe has a unique history of long-term occupation and use of the land and establishment of its tribal government, reservations, rancherias, or other tribal lands. The tribes derived their cultures, commerce, and subsistence primarily from the river and its aquatic and terrestrial resources. This section is organized by tribe to highlight the tribes' individual histories.

The information presented in this section is primarily drawn from the 2012 DOI *Background Technical Report Informing the Secretarial Determination Overview Report: Current Effects of PacifiCorp Dams on Indian Trust Resources and Cultural Values*. This DOI report also provides additional information on tribal trust resources and cultural values for the tribes in the Klamath and Trinity River basins.

Hoopa Valley Tribe The Hoopa Valley Indian Reservation is in the northeastern corner of Humboldt County in northern California, approximately 44 miles upstream from the Klamath estuary. The Reservation encompasses roughly 20 percent of Hupa aboriginal territory. The Reservation, known as "The 12-mile Square," is laid out geometrically with sides approximately 12 miles in length for a total of a little less than 144 square miles. At close to 90,000 acres, and bisected by the Trinity River, the Reservation is the largest in California. A small length of the northern border of the Reservation includes about a quarter mile reach of the Klamath River called Saints Rest Bar, situated several miles upriver from Weitchpec, California. The 2010 census reported Tribal membership to be 2,631 individuals (U.S. Census 2013).

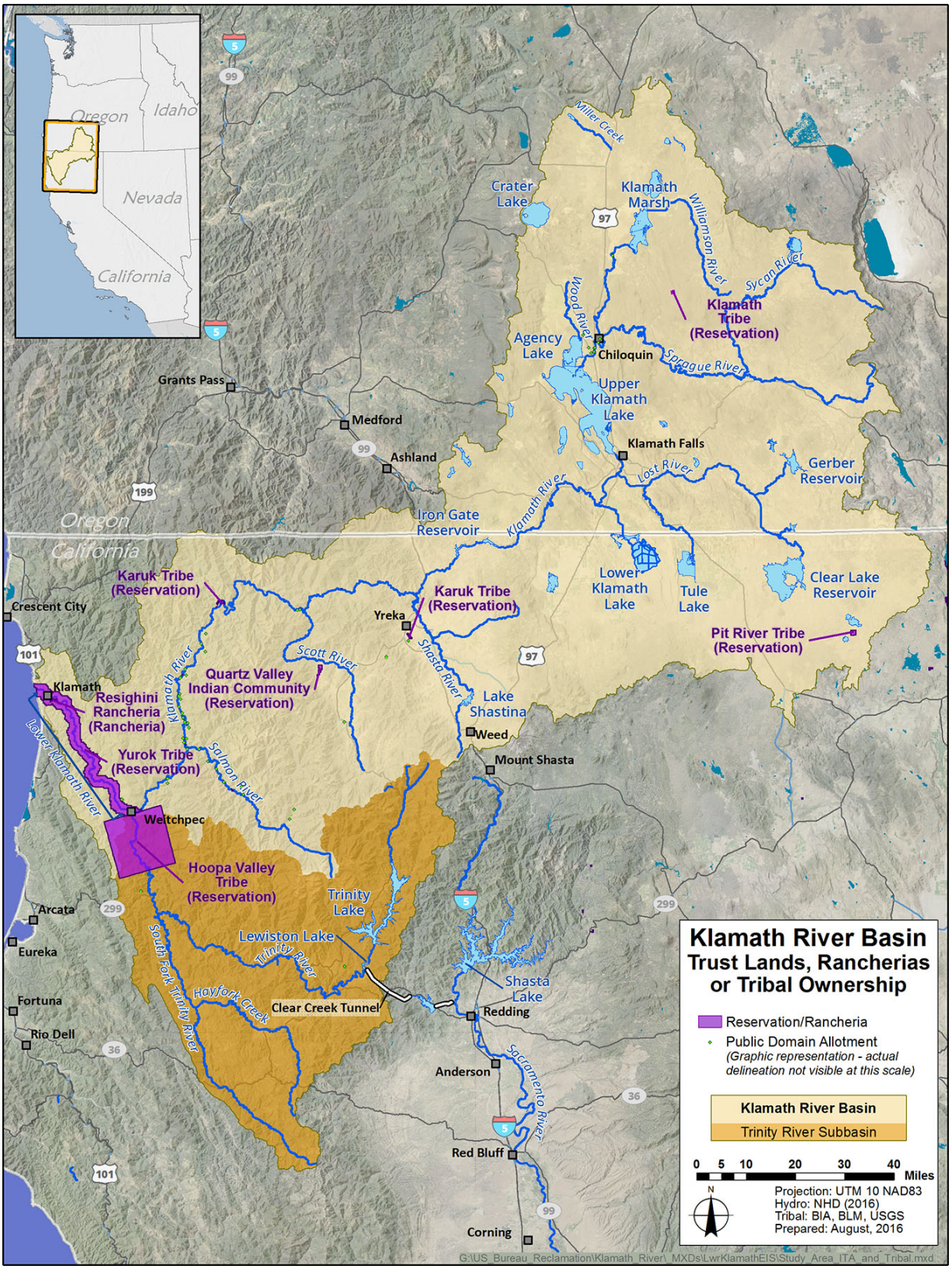

Figure 13-1. Klamath River Basin Trust Lands, Rancherias, and Tribal Ownership

Hoopa Valley Indian Tribe History The Hupa are culturally related to the Yurok and also the Karuk to the north, although the three tribes' traditional languages are entirely different from one another. The word Hupa is from the Yurok name for the Hoopa Valley. Hoopa is used when referring to the name of the Tribe, and Hupa is used when referring to the people, place, or culture. The Hupa called themselves *Natinook-wa*, meaning "People of the Place Where the Trails Return."

The boundaries of the Hoopa Valley Indian Reservation were established by executive order of President Grant on June 23, 1876, pursuant to a Congressional act of 1864. The Reservation was expanded by executive order in 1891 to connect the old Klamath River (Yurok) Reservation with the Hoopa Valley Indian Reservation. From 1891 through 1988 the Hoopa Valley Reservation was composed of the Hoopa Valley 12-mile Square, the extension of the Reservation along the Klamath River, and the original Klamath River Reservation. Confirmation of the sovereignty by the Hoopa Tribe of the Hoopa Valley Indian Reservation came on October 31, 1988, when President Reagan signed Public Law 100-580, the Hoopa-Yurok Settlement Act, again separating the Reservation and retaining the original square Reservation for the Hupa.

Hoopa Valley Tribe Cultural Practices The Trinity River is of prime importance to the Hoopa Valley Tribe because it is the river that runs through the Hoopa Valley Indian Reservation. It is a vital natural resource that is the foundation of their social and cultural way of life. At its most basic level, the river has always been a source for food and other necessities of daily Hupa life, with salmon and acorns providing the bulk of the native diet. Other important fish include steelhead, sturgeon, and lamprey. Fish destined for the Trinity River must pass through the lower Klamath River and are therefore affected by Klamath River conditions. The river also provides basket materials, fish net materials, and a means of transportation. Uses of the Trinity River by the Hupa people are highlighted by maintenance of fisheries and religious ceremonies (e.g., ceremonies that involve prayers offered by people trained to make medicine).

Religious beliefs and practices played an important role in everyday life for the Hupa people. The religion of the Hupa is based on individual effort through ritual cleanliness as well as ceremonies that bring the entire Tribe together. The tribes of the region, including the Hoopa, practice the annual World Renewal Ceremonies, which involve songs and dances that have been preserved for generations. The Hoopa Valley Indians continue to conduct many of their traditional religious ceremonies, and the cultural significance of the Trinity River is captured in many of these ceremonies. The White Deerskin and Jump Dances, the Flower Dance, and the Brush Dance all demonstrate the importance of the river flows to the Hupa people, and how vital the rivers are to Hupa familial and Tribal well-being and self-esteem. Ancient religious sites on the river were believed to be designated by spiritual deities—at a time beyond living memory—and are still used in current Tribal rituals. Prayers conducted at the dances are directed toward the well-being of everyone, and food, particularly fish, is shared with all who attend the ceremonies.

Yurok Tribe of the Yurok Reservation The Yurok Tribe is the largest tribe in California (U.S. Census 2013). As of September 2016, the Yurok Tribe membership was 6,155 individuals (pers comm R. McMahon 2016). The Tribe's ancestral territory covers approximately 350,000 acres and includes approximately 50 miles of Pacific Ocean coastline. Today, the Tribe's Reservation, located in Del Norte and Humboldt Counties, California, encompasses

approximately 57,000 acres, and consists of a strip of land that begins at the Pacific Ocean and extends a mile along each side of the Klamath River (a distance of about 44 miles upriver) to just above the confluence of the Klamath and Trinity Rivers (Yurok 2016). This Reservation configuration came about through a complex series of Federal reports and legislative acts.

Today the Yurok Tribe—headquartered in Klamath, California, with an upriver office located in Weitchpec, California—employs almost 300 people, and has one of the most substantial fishery programs on the entire Klamath River, self-regulating its subsistence and commercial fishery. The Tribe actively participates in the in-river and upslope restoration of its ancestral lands, and has signed a collaborative management agreement with the DOI memorializing the prime role that the Yurok Tribe maintains in managing its resource base.

Yurok Tribe History In 1855, by executive order (pursuant to a Congressional act of March 3, 1853, 10 Stat. 226, 238), President Pierce established the Klamath River Reservation, defined as a strip of land beginning at the Pacific Ocean and extending one mile on each side of the Klamath River for a distance of about 20 miles, an area that was entirely contained within the Yurok's ancestral lands. The government's intention was to eventually move all of the region's Indians onto this Reservation, but only some Yurok and Tolowa were actually moved. Flooding in 1862 forced the closing of the area's Indian Bureau offices at Waukel Flat and Fort Terwer; without a fort, the military withdrew and these withdrawals contributed to the perception that the Reservation had been abandoned. However, the Yurok had continued to occupy the Reservation.

In 1864, the Hoopa Valley Indian Reservation was created on the Trinity River, and in 1876 President Grant issued an executive order that formally established its boundaries. A few years later, in 1885, a special agent for the DOI proposed that the Klamath River Reservation and the Hoopa Valley Reservation be joined. Based on the agent's recommendations, in 1891 President Harrison extended the Hoopa Valley Indian Reservation to the Pacific Ocean, subsuming the connecting strip and the Klamath Reserve and effectively requiring that two culturally-distinct tribes occupy the same reservation called the Hoopa Valley Indian Reservation. As a result of the Indian General Allotment Act of 1887, individual Indians received allotments of tribal land in the former Klamath Reserve and connecting strip portions of the Hoopa Valley Indian Reservation. Eighty-five percent of the remainder of the Yurok portion of the reserve was declared surplus and opened to homesteading by non-Indians.

The Hoopa-Yurok Settlement Act (Public Law 100-580, 102 Stat. 2924), enacted by the U.S. Congress on October 31, 1988, divided the Hoopa Valley Indian Reservation into separate Hoopa and Yurok Reservations and allowed the Yurok to govern themselves through the Yurok Tribal government.

Yurok Cultural Practices Fish are the Yurok Tribe's most valuable asset and a mainstay of their economy. Abundant fish allow Yurok to feed themselves and their families and to acquire products from outside their territory through trade. Fish were the baseline resource that facilitated the acquisition of wealth and upward social mobility in Yurok culture.

The lives of the Yurok people have always been intricately tied to the Klamath River. Historically, they depended on the river for sustenance, and much of their world was defined in terms of their physical relation to the river. Natural and cultural sites, daily and seasonal

ceremonial practices, oral traditions, transportation routes, economic resources, social relationships, and the Yurok identity were all drawn from the river.

First Salmon Ceremonies were initiated around April when fish first breeched the sandbar at the mouth of the Klamath River. The ceremony was conducted to celebrate the harvesting of fish and to pray for continuing prosperity and access to subsistence resources. In early spring, the first salmon to enter the Klamath River was traditionally speared and ritually eaten by Yurok medicine men, which signified the beginning of the fishing season. Salmon are ritually managed to ensure that Yurok are provided with fish and that enough fish spawn to maintain the fishery. Yurok maintain a general reverence for salmon, and a strong belief prevails that without proper ceremony the salmon will not return in sufficient numbers. The river is central to most Yurok ceremonies. There are several rocks along the river etched with petroglyphs that provide instructions from the Creator to the Yurok people.

Many of the Yurok cultural sites on the Klamath and lower Trinity Rivers are traditional fishing spots owned by families. Over time, as the rivers' flows have changed, so have the locations of these cultural sites. To this day, the Yurok continue to live in some of the village sites that line the Klamath and lower Trinity Rivers, where they still practice many of their traditions in places where the Yurok have lived, fished, gathered, prayed, and buried their dead for centuries.

Indian Reserved Rights

By first creating reservations "for Indian Purposes," the United States sought to provide the Hoopa Valley and Yurok Tribes with the opportunity to remain mostly self-sufficient, exercise their rights as sovereigns, and maintain their traditional ways of life (Pevar 1992). Implicit in this objective was an expectation that the Federal Government would protect the tribes and their resources (a protection that extended beyond reservation borders). Specifically relevant to the No Action Alternative and the action alternatives considered in this EIS are the fishing rights, tribal water rights, and rights to wildlife and vegetation resources in the Klamath and Trinity Rivers, as summarized below.

Fishing Rights Salmon, steelhead, sturgeon, and lamprey that spawn in the Trinity River pass through the Hoopa Valley and Yurok Reservations and are harvested in tribal fisheries. The fishing traditions of these tribes stem from practices that far pre-date the arrival of non-Indians. Accordingly, when the Federal government established what are today the Hoopa Valley and Yurok Indian Reservations on the Trinity and lower Klamath Rivers, it reserved for the benefit of the Indian tribes of those reservations a right to the fish resources in the rivers running through them. The United States has long recognized the rights of the tribes of the Lower Klamath and Trinity River Region to fish. The Federal government, as trustee, has an affirmative obligation to manage tribal rights and resources for the benefit of the tribes.

Tribal fishing rights are held in trust by the United States for the benefit of the Indians. These rights have been acknowledged and confirmed by the executive, legislative, and judiciary branches of the Federal government in a number of authorities including: (1) Secretarial Issue Document on Trinity River Fishery Mitigation, issued January 14, 1981; (2) Opinion of the Solicitor of the DOI re: Fishing Rights of the Yurok and Hoopa Valley Tribes (M-36979: October 4, 1993); (3) the Central Valley Project Improvement Act (CVPIA) (3406 (b) (23)); and (4) Parravano v. Babbitt, 837 F. Supp. 1034 (N.D. Calif. 1993), 861 F Supp. 914 (N.D. Calif.

1994), affirmed 70 F.3d 539 (9th Cir. 1995), cert. denied, 518 U.S. 1016 (1996). In most cases, tribal fishing rights cannot be supplanted by State or Federal regulation.

The above referenced 1993 solicitor's opinion: (1) reaffirms the historic and legal basis of the reserved fishing rights of the Hoopa Valley and Yurok Tribes; (2) acknowledges the Federal government's cognizance of the importance of fish to these Indians at the time it first established reservations on their behalf; (3) concludes that the tribes' reserved fishing rights entitle them to what is necessary to support a moderate standard of living, or 50 percent of the harvestable share of the Klamath-Trinity basin fishery, whichever is less; (4) recognizes that under the current depleted condition of the fishery, a 50 percent allocation does not adequately meet the tribes' needs; and (5) argues that it was the degree of the Hoopa Valley and Yurok Tribes' dependence on fisheries at the time their reservations were first created or expanded—and not the tribes' specific uses of the fish—that is relevant in quantifying their fishing rights.

Today, the reserved fishing right includes that right to harvest quantities of fish that the Indians require to maintain a moderate standard of living, unless limited by the 50 percent allocation. Specifically, the tribes have a right to harvest all species of Klamath and Trinity River fish for their subsistence, ceremonial, and commercial needs. Tribal harvest of these species is guided by conservation requirements outlined in carefully developed tribal harvest management plans.

Water Rights The tribes have reserved rights to water. The concept of reserved rights in general—and Indian reserved water rights specifically—originated at the start of the 20th century with Winters v. United States, 207 U.S. 564 (1908). The ruling in this case, commonly referred to as the Winters Doctrine, provides that the establishment of Indian or other Federal reservations also implicitly reserves the water rights necessary to achieve the purposes of those reservations. Generally, all original documents related to the establishment of reservations—treaty, executive order, or statute—indicate, at a minimum, that the purpose of the reservations is to provide a permanent home for the tribe(s) in question. In cases where reservations have been created with specific language stating or implying reserved fishing, hunting, gathering, or other rights, the Winters Doctrine has been interpreted to mean that adequate water supplies for these purposes have been reserved (even in addition to more general uses—see U.S. v. Adair, 723 F.2d 1410[9th Cir. 1983]).

The alternatives in this EIS have important implications for the Federal government's duty to protect those rights. Pursuant to statutory and fiduciary obligations, sufficient water must remain in the Trinity River to support the anadromous fishery and other trust resources.

Rights to Wildlife and Vegetation Resource While the focus of the legal history surrounding Indian rights to resources has mostly focused on water and fisheries, it is important to recognize that other resources (such as wildlife and vegetation) are extremely important to the tribes and no less reserved. In the case of the Hoopa Valley and Yurok Tribes, the decline in the health of the region's rivers has limited the availability of grasses and other plants that are important to traditional basketry, art, and medicine. Thus, while fish are the focus of the action alternatives, other trust assets such as vegetation also fall under the umbrella of the Federal government's trust responsibility and, accordingly, need to be considered in the decision-making process.

Potentially Impacted Indian Trust Assets

Indian tribes of the Lower Klamath and Trinity River Region have firmly established Federally-protected rights to numerous natural resources. These general resources groupings represent culturally important ITAs. A partial list of trust assets—particularly those potentially affected by the action alternatives—is presented in Table 13-1. While each tribe has its own unique uses for the species and resources presented, Table 13-1 provides a general summary of the uses of each asset.

Table 13-1. Partial List of Tribal Trust Assets

Asset	Primary Uses by Tribes
Water	Subsistence, ceremonial, commercial, medicine
Fish[1]	
Fall-run Chinook Salmon	Subsistence, ceremonial, commercial
Spring-run Chinook Salmon	Subsistence, ceremonial, commercial
Summer steelhead	Subsistence, ceremonial, commercial
Fall steelhead	Subsistence, ceremonial, commercial
Winter steelhead	Subsistence, ceremonial, commercial
Coho Salmon	Subsistence, ceremonial, commercial
Pacific Lamprey	Subsistence, ceremonial, commercial
White Sturgeon	Subsistence, ceremonial, commercial
Green Sturgeon	Subsistence, ceremonial, commercial
Eulachon	Subsistence, ceremonial, commercial
Vegetation	
Willow shoots	Basketry, ceremonial
Cottonwood	Basketry
Wild grape	Basketry
Bulrush	Basketry
Hazel sticks	Basketry and weaving, ceremonial
Tules	Medicine
Spearmint	Medicine, subsistence
Blackberries	Subsistence
Wildlife	
Bear	Subsistence
Bald eagle	Ceremonial
Blue heron	Ceremonial
Mallard	Ceremonial

Source: USFWS et al. 2000

Note:

[1] While many of the fish listed are not currently commercially harvested by the tribes of the region, historically, all these trust species were used for commercial purposes, and the tribes continue to have the right for commercial harvest.

Impact Analysis

This section describes the potential mechanisms and analytical methods for change in ITAs; results of the impact analysis; potential mitigation measures; and cumulative effects. Changes in TRD operations under the action alternatives, as compared to the No Action Alternative, could impact tribal trust resources related to water, fisheries, and terrestrial biological resources by changing flows and water quality in the Trinity River and lower Klamath River.

Potential Mechanisms for Change in Indian Trust Assets

The impact analysis considers changes in ITAs related to changes in TRD operations under the action alternatives, as compared to the No Action Alternative.

Impacts to existing ITAs would be considered adverse if the action:

- Interfered with the exercise of a Federally-reserved water right, or degrade water quality where there is a Federally-reserved water right
- Interfered with the use, value, occupancy, character, or enjoyment of an ITA
- Failed to protect ITAs from loss, damage, waste, depletion, or other negative effects

Changes to Trust Resources Related to Fisheries

Changes in fishery resources in the Trinity River and lower Klamath River could directly affect tribal trust fisheries. As described in Chapter 7, "Biological Resources – Fisheries," implementation of action alternatives, as compared to the No Action Alternative, could affect fishery resources in the Trinity River and the lower Klamath River.

Changes to Trust Resources Related to Water

Changes in flow in the Trinity River and lower Klamath River could directly affect trust assets related to water. As described in Chapter 4, "Surface Water Supply and Management," implementation of action alternatives, as compared to the No Action Alternative, could affect flows in the Trinity River and the lower Klamath River.

Changes to Trust Resources Related to Terrestrial Biological Resources

Changes in terrestrial biological resources in the Trinity River and lower Klamath River could directly affect tribal trust wildlife and vegetation. As described in Chapter 8, "Biological Resources – Terrestrial," implementation of action alternatives, as compared to the No Action Alternative, has the potential to affect terrestrial biological resources in the Trinity River and the lower Klamath River.

Evaluation of Alternatives

The impact analysis in this EIS is based upon the comparison of the action alternatives to the No Action Alternative projected for year 2030. The evaluation of alternatives is focused on the Lower Klamath and Trinity River Region because, as discussed above, potential changes that could affect ITAs located along the Klamath and Trinity Rivers.

No Action Alternative

Under the No Action Alternative, ITAs would be comparable to the conditions described in the *Affected Environment* section of this chapter. Conditions in 2030 would be different than existing conditions, primarily due to climate change and sea-level rise, general plan development throughout California, and implementation of reasonable and foreseeable water resource management projects to provide water supplies.

As described in Chapter 7, "Biological Resources – Fisheries," there is a continued risk of a fish die-off from an *Ichthyophthirius multifiliis* (Ich) epizootic in the lower Klamath River under the No Action Alternative. A fish die-off, regardless of apparent causes, would be devastating for the

tribal trust fisheries in the Klamath and Trinity Rivers. The Hoopa Valley Tribe and the Yurok Tribe both depend on the salmon harvest for subsistence, ceremonial, and commercial needs to maintain a moderate standard of living. These Tribes have fished these rivers for thousands of years and tribal culture is deeply connected to the river and the salmon. Without the harvest, these Tribal communities would be greatly impacted. These conditions, combined with the potential of Ich presence in the river, lead to a continued risk for a fish die-off in the lower Klamath River under the No Action Alternative. Fish die-offs would adversely affect tribal trust fisheries.

As described in Chapter 4, "Surface Water Supply and Management," for the Klamath River Basin, temperatures and precipitation are both anticipated to increase. Climate change may also cause changes in stream flows within the Klamath River Basin. Projected warming is anticipated to change runoff timing, with more rainfall runoff during the winter and less runoff during the late spring and summer.

As described in Chapter 8, "Biological Resources – Terrestrial," the No Action Alternative is comparable to the conditions described in the *Affected Environment* section of that chapter. Effects to ITAs related to terrestrial biological resources are anticipated to be the same as those described in Chapter 8.

Proposed Action (Alternative 1)

Lower Klamath and Trinity River Region

Changes to Trust Resources Related to Fisheries As described in Chapter 7, "Biological Resources – Fisheries," the risk of a fish die-off is reduced with the implementation of Alternative 1. Therefore, as compared to the No Action, there are no substantial adverse effects to tribal trust fisheries from the implementation of Alternative 1. Chapter 7 provides additional information on the affects to the Trinity River and lower Klamath River fisheries.

Changes to Trust Resources Related to Water Table 13-2 summarizes average annual changes in Lewiston Dam releases to the Trinity River. As compared to the No Action Alternative, Alternative 1 would increase average annual releases from Lewiston Dam to the Trinity River under all water year types, except in extremely wet years when there is a one percent decrease in flows.

Chapter 4, "Surface Water Supply and Management," provides more information about potential changes in flows within the Trinity River from Trinity Lake downstream to the confluence with the Klamath River, and within the lower Klamath River, from the Trinity River confluence to the Pacific Ocean.

Table 13-2. Changes in Average Annual Lewiston Dam Releases to Trinity River Under Alternative 1 as Compared to the No Action Alternative, by Trinity Water Year Type

Alternative/Comparison	Extremely Wet	Wet	Normal	Dry	Critically Dry	Average All Years
Lewiston Releases to Trinity River						
No Action (TAF)	1,190	868	652	452	364	707
Alternative 1 (TAF)	1,183	874	665	476	405	721
No Action Compared to Alternative 1 (TAF)	-7	6	13	24	41	14
No Action Compared to Alternative 1 (%)	-1%	1%	2%	5%	11%	2%

Key:
% = percent
TAF = thousand acre-feet

Changes to Trust Resources Related to Terrestrial Biological Resources As described in Chapter 8, "Biological Resources – Terrestrial," there are no substantial adverse effects on terrestrial biological resources from the implementation of Alternative 1. Therefore, as compared to the No Action Alternative, there are no substantial adverse effects to tribal trust wildlife and vegetation from the implementation of Alternative 1. Chapter 8 provides additional information on the affects to the Trinity River and lower Klamath River terrestrial biological resources.

Trinity River Record of Decision Flow Rescheduling Alternative (Alternative 2)

Lower Klamath and Trinity River Region

Changes to Trust Resources Related to Fisheries As described in Chapter 7, "Biological Resources – Fisheries," the risk of a fish die-off is reduced with the implementation of Alternative 2. Therefore, as compared to the No Action Alternative, there are no substantial adverse effects to tribal trust fisheries from the implementation of Alternative 2. Chapter 7 provides additional information on the affects to the Trinity River and lower Klamath River fisheries.

Changes to Trust Resources Related to Water Table 13-3 summarizes average annual changes in Lewiston Dam releases to the Trinity River. Releases from Lewiston Dam to the Trinity River are generally similar to the No Action Alternative, with increases of less than, or equal to, three percent under all water year types, except in extremely wet water year types when there is a one percent decrease in flows.

Chapter 4, "Surface Water Supply and Management," provides more information about potential changes in flows within the Trinity River from Trinity Lake downstream to the confluence with the Klamath River, and the lower Klamath River, from the Trinity River confluence to the Paciic Ocean.

Table 13-3. Changes in Average Annual Trinity River Releases Below Lewiston Dam Under Alternative 2 as Compared to the No Action Alternative, by Trinity Water Year Type

Alternative/Comparison	Extremely Wet	Wet	Normal	Dry	Critically Dry	Average All Years
Lewiston Releases to Trinity River						
No Action (TAF)	1,190	868	652	452	364	707
Alternative 2 (TAF)	1,184	870	655	452	376	709
No Action Compared to Alternative 2 (TAF)	-6	2	3	0	12	2
No Action Compared to Alternative 2 (%)	-1%	0%	0%	0%	3%	0%

Key:
% = percent
TAF = thousand acre-feet

Changes to Trust Resources Related to Terrestrial Biological Resources As described in Chapter 8, "Biological Resources – Terrestrial," there are no substantial adverse effects on terrestrial biological resources from the implementation of Alternative 2. Therefore, as compared to the No Action, there are no substantial adverse effects to tribal trust wildlife and vegetation from the implementation of Alternative 2. Chapter 8 provides additional information on the affects to the Trinity River and lower Klamath River terrestrial biological resources.

Summary of Impact Analysis

The results of the impact analysis of implementation of action alternatives, as compared to the No Action Alternative, are presented in Table 13-4.

Table 13-4. Comparison of Action Alternatives to No Action Alternative

Alternative	Potential Change	Consideration for Mitigation Measures
Alternative 1	*Potential Changes to Indian Trust Assets* There are no substantial adverse effects to Indian Trust Assets related to fisheries resources, water, and terrestrial biological resources.	None needed
Alternative 2	*Potential Changes to Indian Trust Resources* There are no substantial adverse effects to Indian Trust Assets related to fisheries resources, water, and terrestrial biological resources.	None needed

Potential Mitigation Measures

Mitigation measures are presented in this section to avoid, minimize, rectify, reduce, eliminate, or compensate for adverse effects to ITAs of the action alternatives, as compared to the No Action Alternative.

There would be no adverse impacts to ITAs, therefore no mitigation measures are needed.

Cumulative Effects Analysis

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 ITAs are summarized in Table 13-5. The methodology for this cumulative effects analysis is described in the Cumulative Effects Technical Appendix.

Table 13-5. Summary of Cumulative Effects on Indian Trust Assets with Implementation of Action Alternatives as Compared to the No Action Alternative

Scenarios	Cumulative Effects of Actions
No Action Alternative with Associated Cumulative Effects Actions in Year 2030	*Conditions and Actions included in Quantitative Analyses* *(Conditions and actions incorporated into No Action Alternative modeling)* Climate change is anticipated to shift winter precipitation from snow to rain, which will lead to larger runoff events in the winter and less snowmelt in the spring. River flows in turn will be reduced during summer months. Lower summer river flows, combined with increases in ambient air temperatures, are expected to cause further increases in water temperatures compared to recent historical conditions. Lower flow and increased temperature conditions during summer months would likely increase the potential for Ich epizootic events and related fish die-offs. *Additional Identified Actions* *(Additional reasonably foreseeable projects or actions identified in Cumulative Effects Technical Appendix)* Additional reasonably foreseeable actions, including the Klamath River Mainstem Dam Removal and Hoopa Valley Tribe Watershed Restoration Projects, are anticipated to improve and increase fish habitat. Improved and increased fish habitat is anticipated to have beneficial effects for tribal trust fisheries resources.
Alternative 1 with Associated Cumulative Effects Actions in Year 2030	*Alternative 1 with Conditions and Actions included in Quantitative Analyses* Implementation of Alternative 1 would result in improved tribal trust fisheries resources as compared to the No Action Alternative. Implementation of Alternative 1 would result in similar tribal trust terrestrial and water resource conditions as compared to the No Action Alternative. *Alternative 1 with Additional Identified Actions* Alternative 1 with the additional reasonably foreseeable action would result in beneficial effects to fish habitat in the Klamath Basin, and therefore cumulative impacts to tribal trust fisheries resources are not anticipated. The additional reasonably foreseeable actions would result in beneficial effects to terrestrial habitats in the Trinity River Subbasin, and therefore cumulative effects to tribal terrestrial resources conditions are not anticipated. Additional reasonably foreseeable actions are not anticipated to affect tribal trust water resource conditions.
Alternative 2 with Associated Cumulative Effects Actions in Year 2030	*Alternative 2 with Conditions and Actions Included in Quantitative Analyses* Implementation of Alternative 2 would result in improved tribal trust fisheries resources as compared to the No Action Alternative. Implementation of Alternative 2 would result in similar tribal trust terrestrial and water resource conditions as compared to the No Action Alternative. *Alternative 2 with Additional Identified Actions* Alternative 2 with the additional reasonably foreseeable action would result in beneficial effects to fish habitat in the Klamath Basin, and therefore cumulative impacts to tribal trust fisheries resources are not anticipated. The additional reasonably foreseeable actions would result in beneficial effects to terrestrial habitats in the Trinity River Subbasin, and therefore cumulative effects to tribal terrestrial resources conditions are not anticipated. Additional reasonably foreseeable actions are not anticipated to affect tribal trust water resource conditions.

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Chapter 14
Environmental Justice

Introduction

This chapter provides the environmental justice analysis to identify and address any disproportionate and adverse impacts on minority or low-income populations that could occur as a result of implementing the alternatives evaluated in this Environmental Impact Statement (EIS). This chapter evaluates the potential for disproportionate and adverse impacts on minority or low-income populations, from changes to tribal fisheries and irrigated agricultural production.

Regulatory Environment and Compliance Requirements

This chapter was prepared in compliance with Presidential Executive Order (EO) 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*, dated February 11, 1994, and Title VI of the Civil Rights Act of 1964, as described below:

- **Executive Order 12898** – EO 12898, issued by President Clinton in 1994, requires that "each Federal agency shall make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations…." In his memorandum transmitting EO 12898 to Federal agencies, President Clinton further specified that, "each Federal agency shall analyze the environmental effects, including human health, economic and social effects, of Federal actions, including effects on minority communities and low-income communities, when such analysis is required by the National Environmental Policy Act of 1969."

- **Title VI of the Civil Rights Act of 1964** – Title VI of the Civil Rights Act of 1964 states that "No person in the United States shall, on the ground of race, color, or national origin be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any program or activity receiving Federal financial assistance." Title VI bars intentional discrimination, but also unjustified disparate impact discrimination resulting from policies and practices that are neutral on their face (i.e., there is no evidence of intentional discrimination) but have the effect of discrimination on protected groups.

Actions that could be implemented under the alternatives evaluated in this EIS could have disproportionately high and adverse human health or environmental effects on minority or low-income populations.

Affected Environment

The conditions described in this chapter are related to the distribution of minority populations and populations below poverty levels.

Area of Analysis

Below, a summary of conditions are described for the following regions that could be affected by the implementation of alternatives analyzed:

- Lower Klamath and Trinity River Region
- Central Valley and the Bay-Delta Region

Characterization of Conditions Considered in the Environmental Justice Analysis

Characterization of the conditions within the Lower Klamath and Trinity River Region and the Central Valley Region and Bay-Delta Region is based upon publicly-available data from government websites and other statistical sources. The data sources used include the 2010 U.S. Census Bureau data on minority populations and the 2010 American Community Survey (ACS) five-year population estimates on populations below the poverty level. The 2011-2015 ACS survey is not anticipated to be released until late 2016 or early 2017, therefore, that data is not represented in this chapter.

Determination of Minority Populations

Minority populations are defined by the U.S. Census Bureau as racial and ethnic minorities. Racial minorities, as defined by the U.S. Census Bureau, include people who identified themselves in the census as belonging to one of the following categories:

- Single Race
  - Black/African American
  - American Indian and Alaskan Native
  - Asian
  - Native Hawaiian and Other Pacific Islander
  - Some Other Race
- Two or More Races (inclusive of the races listed above and White).

Ethnic minorities, as defined by the U.S. Census Bureau, include individuals who identified themselves as being of Hispanic or Latino origin by identifying with one of the following categories in the census:

- Mexican
- Mexican American

- Chicano
- Puerto Rican
- Cuban
- Other Spanish/Hispanic/Latino

Individuals who identified themselves of Hispanic or Latino origin may be of one or more races according to the U.S. Census Bureau.

Determination of Populations Below the Poverty Level

Populations below the Federal poverty level can be identified using several methodologies. The information presented in this chapter has been developed in ACS reports by the U.S. Census Bureau based upon 48 different sets of dollar-value thresholds related to family size and ages. The poverty level is assigned at the family-level and affects every member of the family. The thresholds are consistent throughout the United States and do not consider geographic differentials. The thresholds are updated each year based on the Consumer Price Index. For the five-year ACS reporting period used in this chapter, separate thresholds are applied to each year in this continuous survey.

The population values to determine poverty rates do not include institutionalized individuals (e.g., military personnel that live in group quarters, students that live in college dormitories, and prison inmates). The U.S. Census Bureau designates geographical areas with poverty rates at and above 20 percent as *poverty areas*.

Social Services

The need for, and delivery of, social services within each county is another indication of social conditions. These include Federal grants to State and local agencies for Medicaid, other health-related activities, nutrition and family welfare, Federal direct payments made to individuals under the CalFresh program (previously referred to as *Food Stamps*), and supplemental social security income.

Lower Klamath and Trinity River Region

The Lower Klamath and Trinity River Region for this analysis includes the area in Trinity County along the Trinity River, from Trinity Lake to its confluence with the Klamath River; and in Humboldt and Del Norte Counties along the lower Klamath River from the confluence with the Trinity River to the Pacific Ocean. Tribal lands along the Trinity or lower Klamath Rivers within the Trinity River Region include the Hoopa Valley Indian Reservation, Yurok Indian Reservation, and Resighini Rancheria.

Minority Populations

Table 14-1 provides a summary of the minority population distribution in the Lower Klamath and Trinity River Region as compared to the State of California. There are fewer minorities in the Lower Klamath and Trinity River Region than in the entire State; however, there are a distinctively higher percentage of American Indian and Native Alaskan populations in all three counties compared to the statewide percentage.

Table 14-1. Minority Population Distribution in Lower Klamath and Trinity River Region in 2010

Areas	Total Population	Races							Hispanic or Latino Origin	Total Minority[a]
		White	Black/ African American	American Indian and Native Alaskan	Asian	Native Hawaiian and Other Pacific Islander	Some Other Race	Two or More Races		
Trinity County	13,786	87.3%	0.4%	4.8%	0.7%	0.1%	1.6%	5.2%	7.0%	16.5%
Humboldt County	134,623	81.7%	1.1%	5.7%	2.2%	0.3%	3.7%	5.3%	9.8%	22.8%
Del Norte County	28,610	73.7%	3.5%	7.8%	3.4%	0.1%	6.9%	4.5%	17.8%	35.3%
State of California	37,253,956	57.6%	6.2%	1.0%	13.0%	0.4%	17.0%	4.9%	40.1%	59.9%

Sources: U.S. Census 2016a

Note:

a. Total Minority is an aggregation of all non-white racial groups and includes all individuals of Hispanic or Latino origin, regardless of race.

Key:

% = percent

Poverty Levels

Poverty levels presented in Table 14-2 are calculated on a subset of the total population of a county, as described above in the *Determination of Populations below the Poverty Level* section

Table 14-2. Population Below Poverty Level in Lower Klamath and Trinity River Region, 2006 – 2010

Areas	Total Population[a]	Population Below Poverty Level	Percent of Population Below Poverty Level
Trinity County	13,225	1,993	15.1%
Humboldt County	129,592	22,973	17.7%
Del Norte County	25,170	5,526	22.0%
State of California	35,877,036	4,919,945	13.7%

Source: U.S. Census 2016b

Note:

[a] Population numbers are only those for whom poverty status was determined and excludes institutionalized individuals.

Key:

% = percent

The U.S. Census Bureau defines geographical areas with more than 20 percent of the population below the poverty level as a poverty area. In the Lower Klamath and Trinity River Region, Del Norte County is defined as a poverty area.

Poverty rates based upon the 2000 census were reported as: 40 percent for Indians on the Yurok Indian Reservation, 34 percent of the Indians on the Hoopa Valley Indian Reservation, and 54 percent of the Indians on and off Karuk Reservation trust lands (NMFS 2012a, 2012b, 2012c). The Yurok Tribe has reported an average poverty rate of 80 percent of the Indians on the Yurok Indian Reservation (Yurok 2016). Average per capita income of residents on the Resighini Rancheria (not limited to Resighini Rancheria members) in 1999 was reported to be approximately 46 percent of the average per capita income in Del Norte County (NMFS 2012d). Poverty rates from the 2010 census were not available for Native American tribes.

Social Services

Table 14-3 provides a summary of the Federal funds distributed for social programs in the Lower Klamath and Trinity River Region in 2010 as compared to the State of California.

Table 14-3. Federal Funds Distributed for Social Programs in the Lower Klamath and Trinity River Region in 2010

Areas	Grants (millions of dollars)		Distributed to Individuals (millions of dollars)
	Medicaid and Other Health-Related Items	Nutrition and Family Welfare	CalFresh Benefits and Supplemental Security Income
Trinity County	$12.5	$4.9	$6.6
Humboldt County	$167.8	$36.0	$65.6
Del Norte County	$28.8	$10.1	$19.1
State of California	$41,931.1	$11,743.7	$12,469.4

Source: Gaquin and Ryan 2013

Central Valley and Bay-Delta Region

The Central Valley Region extends from above Shasta Lake south to the Tehachapi Mountains, and includes the Sacramento Valley and San Joaquin Valley.

Sacramento Valley

The Sacramento Valley includes 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 operations, and are not discussed here, including: Alpine, Sierra, Lassen, and Amador Counties.

Minority Populations Table 14-4 provides a summary of the minority population distribution in the Sacramento Valley as compared to the State of California. Colusa, Sacramento, Yolo and Solano Counties had over 50 percent of the county that identified themselves as a racial minority or of Hispanic or Latino origin, regardless of race, as presented in Table 14-4.

Poverty Levels Poverty levels presented in Table 14-5 are calculated on a subset of the total population of a county, as described above in the *Determination of Populations Below the Poverty Level* section.

The U.S. Census Bureau defines geographical areas with more than 20 percent of the population below the poverty level as a poverty area. Under these terms, Tehama and Yuba Counties are defined as poverty areas.

Social Services Table 14-6 provides a summary of the Federal funds distributed for social programs in the Sacramento Valley in 2010 as compared to the State of California.

Table 14-4. Minority Population Distribution in the Sacramento Valley in 2010

Areas	Total Population	Races							Hispanic or Latino Origin	Total Minority[a]
		White	Black/ African American	American Indian and Native Alaskan	Asian	Native Hawaiian and Other Pacific Islander	Some Other Race	Two or More Races		
Shasta County	177,223	86.7%	0.9%	2.8%	2.5%	0.2%	2.5%	4.4%	8.4%	17.6%
Plumas County	20,007	89.0%	1.0%	2.7%	0.7%	0.1%	3.0%	3.6%	8.0%	15.0%
Tehama County	63,463	81.5%	0.6%	2.6%	1.0%	0.1%	9.9%	4.3%	21.9%	28.1%
Glenn County	28,122	71.1%	0.8%	2.2%	2.6%	0.1%	19.6%	3.6%	37.5%	44.1%
Colusa County	21,419	64.7%	0.9%	2.0%	1.3%	0.3%	27.3%	3.6%	55.1%	60.2%
Butte County	220,000	81.9%	1.6%	2.0%	4.1%	0.2%	5.5%	4.7%	14.1%	24.8%
Yuba County	72,155	68.4%	3.3%	2.3%	6.7%	0.4%	11.8%	7.1%	25.0%	41.2%
Nevada County	98,764	91.4%	0.4%	1.1%	1.2%	0.1%	2.7%	3.2%	8.5%	13.5%
Sutter County	94,737	61.0%	2.0%	1.4%	14.4%	0.3%	15.3%	5.6%	28.8%	49.6%
Placer County	348,432	83.5%	1.4%	0.9%	5.9%	0.2%	3.8%	4.3%	12.8%	23.9%
El Dorado County	181,058	86.6%	0.8%	1.1%	3.5%	0.2%	4.0%	3.8%	12.1%	20.1%
Sacramento County	1,418,788	57.5%	10.4%	1.0%	14.3%	1.0%	9.3%	21.6%	21.6%	51.6%
Yolo County	200,849	63.2%	2.6%	1.1%	13.0%	0.5%	13.9%	30.3%	30.3%	50.1%
Solano County	413,344	51.0%	14.7%	0.8%	14.6%	0.9%	10.5%	24.0%	24.0%	59.2%
State of California	37,253,956	57.6%	6.2%	1.0%	13.0%	0.4%	17.0%	4.9%	37.6%	59.9%

Sources: U.S. Census 2016a

Note:

a. Total Minority is an aggregation of all non-white racial groups and includes all individuals of Hispanic or Latino origin, regardless of race.

Key:

% = percent

Table 14-5. Population below Poverty Level in the Sacramento Valley, 2006–2010

Areas	Total Population[a]	Population Below Poverty Level	Percent of Population Below Poverty Level
Shasta County	174,180	28,772	16.5%
Plumas County	20,179	2,437	12.1%
Tehama County	61,201	12,397	20.3%
Glenn County	27,853	4,875	17.5%
Colusa County	20,768	3,107	15.0%
Butte County	21,3501	39,290	18.4%
Yuba County	68,848	13,750	20.0%
Nevada County	97,209	8,740	9.0%
Sutter County	92,477	13,194	14.3%
Placer County	334,718	22,090	6.6%
El Dorado County	177,660	14,003	7.9%
Sacramento County	1,368,693	190,768	13.9%
Yolo County	186,800	31,895	17.1%
Solano County	397,576	41,158	10.4%
State of California	35,877,036	4,919,945	13.7%

Source: U.S. Census 2016b

Note:

[a] Population numbers are only those for whom poverty status was determined and excludes institutionalized individuals

Key:

% = percent

Table 14-6. Federal Funds Distributed for Social Programs in the Sacramento Valley in 2010

Areas	Grants (millions of dollars)		Distributed to Individuals (millions of dollars)
	Medicaid and Other Health- Related Items	Nutrition and Family Welfare	CalFresh Benefits and Supplemental Security Income
Shasta County	$199.0	$50.8	$93.5
Plumas County	$19.3	$7.9	$5.9
Tehama County	$61.6	$17.5	$23.1
Glenn County	$25.3	$10.6	$11.3
Colusa County	$18.6	$8.2	$6.5
Butte County	$236.4	$44.7	$104.9
Yuba County	$125.0	$21.8	$45.2
Nevada County	$53.8	$15.4	$16.1
Sutter County	$76.4	$20.1	$28.8
Placer County	$139.2	$44.8	$43.2
El Dorado County	$62.5	$32.4	$29.0
Sacramento County	$2,115.5	$2,695.9	$659.1
Yolo County	$504.8	$39.7	$55.2
Solano County	$264.2	$71.7	$118.6
State of California	$41,931.1	$11,743.7	$12,469.4

Source: Gaquin and Ryan 2013

San Joaquin Valley

The San Joaquin Valley includes Stanislaus, Merced, Madera, Fresno, Kings, Tulare, Kern, and San Joaquin Counties. Other counties in the San Joaquin Valley are not anticipated to be affected by changes in CVP operations, and are not discussed here.

Minority Populations Table 14-7 provides a summary of the minority population distribution in the Sacramento Valley as compared to the State of California. All of the San Joaquin Valley counties had over 50 percent of the county that identified themselves as a racial minority or of Hispanic or Latino origin, regardless of race, as presented in Table 14-7.

Poverty Levels Poverty levels presented in Table 14-8 are calculated on a subset of the total population of a county, as described above in the *Determination of Populations Below the Poverty Level* section.

The U.S. Census Bureau defines geographical areas with more than 20 percent of the population below the poverty level as poverty areas. Merced, Fresno, Tulare, and Kern Counties are defined as poverty areas and have the highest concentration of total minority populations. There are communities within these counties that have higher concentrations of minority populations or populations below the poverty level. These communities are mainly farming communities that may be impacted by loss in agricultural employment.

Social Services Table 14-9 provides a summary of the Federal funds distributed for social programs in the San Joaquin Valley in 2010 as compared to the State of California.

Table 14-7. Minority Population Distribution in the San Joaquin Valley in 2010

Areas	Total Population	Races							Hispanic or Latino Origin	Total Minority[a]
		White	Black/ African American	American Indian and Native Alaskan	Asian	Native Hawaiian and Other Pacific Islander	Some Other Race	Two or More Races		
Stanislaus	514,453	65.6%	2.9%	1.1%	5.1%	0.7%	19.3%	5.4%	41.9%	53.3%
Madera	150,865	62.6%	3.7%	2.7%	1.9%	0.1%	24.8%	4.2%	53.7%	62.0%
Merced	255,793	58.0%	3.9%	1.4%	7.4%	0.2%	24.5%	4.7%	54.9%	68.1%
Fresno	930,450	55.4%	5.3%	1.7%	9.6%	0.2%	23.3%	4.5%	50.3%	67.3%
Tulare	442,179	60.1%	1.6%	1.6%	3.4%	0.1%	29.0%	4.2%	60.6%	67.4%
Kings	152,982	54.3%	7.2%	1.7%	3.7%	0.2%	28.1%	4.9%	50.9%	64.8%
Kern	839,631	59.5%	5.8%	1.5%	4.2%	0.1%	24.3%	4.5%	49.2%	61.4%
San Joaquin County	685,306	51.0%	7.6%	1.1%	14.4%	0.5%	19.1%	38.9%	38.9%	64.1%
State of California	37,253,956	57.6%	6.2%	1.0%	13.0%	0.4%	17.0%	4.9%	37.6%	59.9%

Sources: U.S. Census 2016a

Note:

[a] Total Minority is an aggregation of all non-white racial groups and includes all individuals of Hispanic or Latino origin, regardless of race.

Key:

% = percent

Table 14-8. Population Below Poverty Level in the San Joaquin Valley, 2006 – 2010

Areas	Total Population[a]	Population Below Poverty Level	Percent of Population Below Poverty Level
Stanislaus	502,108	82,480	16.4%
Madera	138,151	26,656	19.3%
Merced	246,260	53,738	21.8%
Fresno	890,694	200,288	25.5%
Tulare	423,902	97,012	22.9%
Kings	133,206	25,713	19.3%
Kern	777,622	159,967	20.6%
San Joaquin County	657,594	105,502	16.0%
State of California	35,877,036	4,919,945	13.7%

Source: U.S. Census 2016b

Note:

[a] Population numbers are only those for whom poverty status was determined and excludes institutionalized individuals

Key:

% = percent

Table 14-9. Federal Funds Distributed for Social Programs in the San Joaquin Valley in 2010

Areas	Grants (millions of dollars)		Distributed to Individuals (millions of dollars)
	Medicaid and Other Health-Related Items	Nutrition and Family Welfare	CalFresh Benefits and Supplemental Security Income
Stanislaus	$535.9	$145.3	$198.7
Madera	$144.3	$33.6	$45.6
Merced	$260.0	$73.7	$126.0
Fresno	$992.0	$274.8	$468.5
Tulare	$569.1	$116.0	$196.5
Kings	$129.2	$37.8	$49.3
Kern	$712.0	$203.4	$328.6
San Joaquin County	$739.1	$153.5	$287.4
State of California	$41,931.1	$11,743.7	$12,469.4

Source: Gaquin and Ryan 2013

Impact Analysis

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

Potential Mechanisms for Change and Analytical Methods

The impact analysis considers changes in factors that affect minority and low-income populations, specifically related to changes in CVP operations that would be brought about by implementing one of the alternatives.

The Council of Environmental Quality (CEQ) and U.S. Environmental Protection Agency established guidelines to assist Federal agencies in the analysis of environmental justice effects (CEQ 1997). The following guidelines are used to determine if minority populations are present in the study area:

- The minority population of the affected area exceeds 50 percent, or
- The population percentage of the affected area is meaningfully greater than the minority population percentage in the general population or other appropriate unit of geographical analysis.

The CEQ guidelines do not specifically state the percentage considered meaningful in the case of low-income populations. The CEQ guidelines state that low-income populations in an affected area should be identified with the annual statistical poverty thresholds from the U.S. Census Bureau's Current Population Reports. Therefore, since the U.S. Census Bureau defines areas with more than 20 percent of the population below the poverty level as poverty areas, this same percentage is used to determine low-income populations for purposes of this analysis.

The alternatives considered in this EIS do not include project-specific construction activities. In most portions of the study area, the availability of CVP water supplies directly or indirectly affects most of the population within a county. Therefore, the entire population of each county

within the study area is considered, to determine whether minority or low-income areas could be affected by implementation of the alternatives.

In the Lower Klamath and Trinity River Region and the Central Valley and Bay-Delta Region, low-income populations include Tehama, Yuba, Merced, Fresno, Tulare and Kern Counties.

In the Central Valley and Bay-Delta Region, the following counties have 50 percent or more of the total population as minority populations: Colusa, Sacramento, Yolo, Solano, Stanislaus, Madera, Merced, Fresno, Tulare, Kings, Kern, and San Joaquin Counties.

Although the majority of the populations in the Lower Klamath and Trinity River Region counties are not minority or low-income populations, these counties do include the Hoopa Valley Indian Reservation, Yurok Indian Reservation, and Resighini Rancheria. Therefore, the Trinity River Region counties are also included in the environmental justice analysis because of the high percentage of Indian populations, consistent with CEQ guidance.

The CEQ guidance provides three factors to be considered for determination if disproportionately high and adverse impacts may accrue to minority or low-income populations. The following criteria were used to evaluate the impacts to minority and low-income populations resulting from the operational changes following the implementation of each of the alternatives, as compared to the No Action Alternative:

- Whether there is or will be an impact on the natural or physical environment that significantly (as employed by National Environmental Policy Act (NEPA)) and adversely affects a minority population, low-income population, or Indian tribe. Such effects may include ecological, cultural, human health, economic, or social impacts on minority communities, low-income communities, or Indian tribes when those impacts are interrelated on the natural or physical environment; and

- Whether the environmental effects are significant (as employed by NEPA) and are or may be having an adverse impact on minority populations, low-income populations, or Indian tribes that appreciably exceeds, or is likely to appreciably exceed, those on the general population or other appropriate comparison group; and

- Whether the environmental effects occur, or would occur, in a minority population, low-income population, or Indian tribe affected by cumulative or multiple adverse exposures from environmental hazards.

The environmental justice guidance documents do not specifically define conditions that would result in “high and adverse human health and environmental impact.” For this analysis, the potential changes to water supply and fish populations were considered within the counties that had a minority population of 50 percent or greater of the total population.

The changes were analyzed to determine if the impacts would be disproportionally high on the minority or low-income populations or Indian tribes, in comparison to the total population. Potential adverse impacts were evaluated with regard to changes in CVP operations under the alternatives that could result in disproportionally high effects on minority or low-income

populations or Indian tribes, due to changes in irrigated agricultural production and fish populations.

Potential changes in Irrigated Agricultural Production Affecting Minority or Low-Income Populations or Indian Tribes

Changes in CVP operations under the alternatives could result in reduced water deliveries to the CVP. To evaluate the potential changes in irrigated agricultural production, value, and employment due to changes in CVP water supplies—that may affect minority or low-income populations or Indian tribes—results from Chapter 11, "Agricultural Resources," and Chapter 12, "Socioeconomics," were used.

Changes in Fish Population Due to Fish Die-Off from Ich Disease Affecting Minority or Low-Income Populations or Indian Tribes

To evaluate the potential effects on minority populations, low-income populations, and Indian tribes from changes in fish population (including fish die-off from *Ichthyophthirius multifiliis* (Ich) disease), results from Chapter 7, "Biological Resources – Fisheries," were used. In addition, to evaluate the changes to tribal fisheries due to changes in river flows, river temperatures, and fish health, results from Chapter 12, "Socioeconomics," were analyzed.

Evaluation of Alternatives

Action alternatives have been compared to the No Action Alternative.

No Action Alternative

Potential Changes in Irrigated Agricultural Production Affecting Minority or Low-Income Populations or Indian Tribes Under the No Action Alternative, effects on minority or low-income populations or Indian tribes (due to changes in irrigated agricultural production conditions) would be similar to conditions described in the *Affected Environment* section of this chapter.

Conditions in 2030 would be different than existing conditions, primarily due to climate change and sea-level rise, general plan development throughout California, and implementation of reasonable and foreseeable water resource management projects to provide water supplies. Climate change and sea-level rise are anticipated to reduce long-term average CVP water supply deliveries by 2030, as compared to recent historical long-term average deliveries. These reduced deliveries could result in more crop idling or changes in cropping patterns, and changes in regional income and employment. The No Action Alternative assumes implementation of a number of conservation efforts and major water supply projects by 2030 that would provide additional water supply flexibility and availability.

Changes in Fish Population Due to Fish Die-Off from Ich Disease Affecting Minority or Low-Income Populations or Indian Tribes Under the No Action Alternative, the flows in the lower Klamath River are anticipated to fall under 2,800 cubic feet per second during late August and September in most years. These conditions, combined with the potential of Ich presence in the river, lead to an increased risk for a fish die-off in the lower Klamath River under the No Action Alternative. Fish die-offs would impact the people who rely on salmon for food, by increasing costs to purchase other food sources. This could disproportionally affect the Yurok and Karuk Indian Reservations whose poverty levels are above 50 percent.

Proposed Action (Alternative 1)

Lower Klamath and Trinity River Region

Potential Changes in Irrigated Agricultural Production Affecting Minority or Low-Income Populations or Indian Tribes There are no agricultural lands irrigated with CVP water supplies in the Lower Klamath and Trinity River Region. Therefore, there would be no changes in irrigated lands under Alternative 1 as compared to the No Action Alternative.

Changes in Fish Population Due to Fish Die-Off from Ich Disease Affecting Minority or Low-Income Populations or Indian Tribes During August and September, Trinity River flows would be increased (through augmentation flows) to reduce the likelihood of a disease outbreak in the lower Klamath River in years when the flow in the lower Klamath River are low—less than 2,800 cubic feet per second (cfs)—under Alternative 1. Flow augmentation under Alternative 1 would increase cross-sectional channel area to expand habitat space, increase water velocities that can reduce efficacy of Ich parasites from finding and attaching to adult salmon hosts, potentially provide migration cues to further disperse adult salmon and reduce densities and reduce the frequency of water temperatures exceeding 73.4 degrees Fahrenheit (°F). These conditions would be expected to result in reduced risk of Ich infection, epizootic outbreaks and consequent fish die-offs. This could result in the benefit of reduced cost to the Indian tribes that rely on salmon for food (i.e., Yurok, Karuk, and Hoopa Valley Tribes).

Central Valley and Bay-Delta Region

Potential Changes in Irrigated Agricultural Production Affecting Minority or Low-Income Populations or Indian Tribes As stated in Chapter 12, "Socioeconomics," the direct changes in agricultural production in dry and critical years would result in changes to employment and regional economic output in the Sacramento and San Joaquin Valleys. In the Sacramento Valley, the small decrease in agricultural production would lead to small decreases in related indirect and induced economic output and employment. In the San Joaquin Valley, small increases in agricultural production would lead to small increases in related indirect and induced economic output and employment.

The small decreases in related indirect and induced economic output and employment could affect populations in Tehama, Yuba, Sacramento, Yolo or Solano Counties. These counties have 50 percent or more of the total population as minority populations or are considered low-income populations. However, this change does not disproportionally affect these populations because all segments of the economy (related to agriculture) would be equally affected across the region.

The decreased net revenue to farmers in the San Joaquin Valley could affect populations in Fresno, Tulare, Merced, Kern and Kings Counties. These counties have 50 percent or more of the total population as minority populations or are considered to have low-income populations. However, this change does not disproportionally affect these populations because all segments of the economy related to agriculture would be equally affected across the region.

Changes in Fish Population Due to Fish Die-Off from Ich Disease Affecting Minority or Low-Income Populations or Indian Tribes There are no changes to fish populations due to Ich disease fish die-off in the Central Valley and Bay-Delta Region. Therefore, there would be no changes to fish populations under Alternative 1.

Trinity River Record of Decision Flow Rescheduling Alternative (Alternative 2)

Lower Klamath and Trinity River Region

Potential Changes in Irrigated Agricultural Production Affecting Minority or Low-Income Populations or Indian Tribes There are no agricultural lands irrigated with CVP water supplies in the Lower Klamath and Trinity River Region. Therefore, there would be no changes in irrigated lands under Alternative 2.

Changes in Fish Population Due to Fish Die-Off from Ich Disease Affecting Minority or Low-Income Populations or Indian Tribes During August and September, Trinity River flows would be increased (through augmentation flows) to reduce the likelihood of a disease outbreak in the lower Klamath River in years when the flow in the lower Klamath River are low—less than 2,800 cfs—under Alternative 2. Flow augmentation under Alternative 2 would increase cross-sectional channel area to expand habitat space, increase water velocities that can reduce efficacy of Ich parasites from finding and attaching to adult salmon hosts, potentially provide migration cues to further disperse adult salmon and reduce densities and reduce the frequency of water temperatures exceeding 73.4°F. These conditions would be expected to result in reduced risk of Ich infection, epizootic outbreaks and consequent fish die-offs. This could result in the benefit of reduced cost to the Indian tribes that rely on salmon for food (i.e., Yurok, Karuk, and Hoopa Valley Tribes).

Central Valley Region and Bay-Delta Region

Potential Changes in Irrigated Agricultural Production Affecting Minority or Low-Income Populations or Indian Tribes As stated in Chapter 12, "Socioeconomics," agricultural production value under long-term average, and dry and critical year conditions, would not change under Alternative 2. In addition, employment and regional economic output in the Sacramento and San Joaquin Valleys—including those counties that have 50 percent or more of the total population as minority populations—would also not change.

Changes in Fish Population Due to Fish Die-Off from Ich Disease Affecting Minority or Low-Income Populations or Indian Tribes There are no changes to fish populations due to fish die-off from Ich disease in the Central Valley and Bay-Delta Region. Therefore, there would be no changes to fish populations under Alternative 2.

Summary of Environmental Consequences

The results of the environmental consequences, of implementation of action alternatives as compared to the No Action Alternative, are presented in Table 14-10.

Table 14-10. Comparison of Action Alternatives to No Action Alternative

Alternative	Potential Change	Consideration for Mitigation Measures
Alternative 1	No disproportionately high and adverse effects on low-income or minority populations or Indian tribes.	None needed
Alternative 2	No disproportionately high and adverse effects on low-income or minority populations or Indian tribes.	None needed

Potential Mitigation Measures

Mitigation measures are presented in this section to avoid, minimize, rectify, reduce, eliminate, or compensate for adverse environmental effects of implementing one of the action alternatives.

Changes in CVP operations under action alternatives would not result in changes in irrigated agricultural production that would disproportionally affect minority or low-income populations or Indian tribes. Also, changes in fish population due to fish die-off from Ich disease would not disproportionally affect minority or low-income populations or Indian tribes. Therefore, there would be no disproportionately high or adverse environmental effects on minority or low-income populations or Indian tribes; and no mitigation measures are required.

Cumulative Effects Analysis

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 action alternatives for environmental justice are summarized in Table 14-11. The methodology for this cumulative effects analysis is described in the Cumulative Effects Technical Appendix.

Table 14-11. Summary of Cumulative Effects on Environmental Justice of Alternatives 1 and 2 as Compared to the No Action Alternative

Scenarios	Cumulative Effects of Actions
No Action Alternative with Associated Cumulative Effects Actions in Year 2030	*Conditions and Actions included in Quantitative Analyses* *(Conditions and actions incorporated into No Action Alternative modeling)* *Irrigated Agricultural Production Affecting Minority or Low-Income Populations or Indian Tribes* Climate change and sea-level rise, development under general plans, Federal Energy Regulatory Commission relicensing projects, and some future projects to improve water quality or habitats are anticipated to reduce the availability of CVP water supplies as compared to past conditions. Reductions in CVP water supply reliability may result in changes in agricultural production, including changes in irrigated acres and crop types. *Changes in Fish Population Due to Fish Die-Off from Ich Disease Affecting Minority or Low-Income Populations or Indian Tribes* Climate change is anticipated to shift winter precipitation from snow to rain, which will lead to larger runoff events in the winter and less snowmelt in the spring. River flows in turn will be reduced during summer months. Lower river flows, combined with increases in ambient air temperatures, are expected to cause further increases in water temperatures compared to recent historical conditions. Lower flow and increased temperature conditions during summer months would likely result in poorer habitat conditions, and increase the potential for Ich epizootic events and related fish die-offs. *Additional Identified Actions* *(Additional projects identified in Cumulative Effects Technical Appendix)* *Irrigated Agricultural Production Affecting Minority or Low-Income Populations or Indian Tribes* Additional reasonably foreseeable actions under this cumulative effects analysis are not anticipated to change CVP water deliveries, agricultural production, or water-related employment. *Changes in Fish Population Due to Fish Die-Off from Ich Disease Affecting Minority or Low-Income Populations or Indian Tribes* Additional foreseeable actions, including the Klamath River Main Stem Dam Removal and Hoopa Valley Tribe Watershed Restoration Projects, are anticipated to improve and increase fish habitat. Improved and increased fish habitat is anticipated to have beneficial effects to fish populations.

Table 14-11. Summary of Cumulative Effects on Environmental Justice of Alternatives 1 and 2 as Compared to the No Action Alternative (contd.)

Scenarios	Cumulative Effects of Actions
Alternative 1 with Associated Cumulative Effects Actions in Year 2030	*Alternative 1 with Conditions and Actions included in Quantitative Analyses* *Irrigated Agricultural Production Affecting Minority or Low-Income Populations or Indian Tribes* Implementation of Alternative 1 would result in similar agricultural production and related employment as under the No Action Alternative. *Changes in Fish Population Due to Fish Die-Off from Ich Disease Affecting Minority or Low-Income Populations or Indian Tribes* Implementation of Alternative 1 would result in reduced likelihood of fish-die offs and increased likelihood of maintaining fish populations compared to the No Action Alternative. *Alternative 1 with Additional Identified Actions* *Irrigated Agricultural Production Affecting Minority or Low-Income Populations or Indian Tribes* The additional reasonably foreseeable actions are not anticipated to affect agricultural production and related employment. *Changes in Fish Population Due to Fish Die-Off from Ich Disease Affecting Minority or Low-Income Populations or Indian Tribes* Alternative 1 with the additional reasonably foreseeable actions would result in reduced likelihood of fish die-offs and increased likelihood of maintaining fish populations, and therefore cumulative effects to fish populations are not anticipated.
Alternative 2 with Associated Cumulative Effects Actions in Year 2030	*Alternative 2 with Conditions and Actions included in Quantitative Analyses* *Irrigated Agricultural Production Affecting Minority or Low-Income Populations or Indian Tribes* Implementation of Alternative 2 would result in similar agricultural production and related employment as under the No Action Alternative. *Changes in Fish Population Due to Fish Die-Off from Ich Disease Affecting Minority or Low-Income Populations or Indian Tribes* Implementation of Alternative 2 would result in reduced likelihood of fish-die offs and increased likelihood of maintaining fish populations compared to the No Action Alternative. *Alternative 2 with Additional Identified Actions* *Irrigated Agricultural Production Affecting Minority or Low-Income Populations or Indian Tribes* The additional reasonably foreseeable actions are not anticipated to affect agricultural production and related employment. *Changes in Fish Population Due to Fish Die-Off from Ich Disease Affecting Minority or Low-Income Populations or Indian Tribes* Alternative 2 with the additional reasonably foreseeable actions would result in reduced likelihood of fish-die offs and increased likelihood of maintaining fish populations, and therefore cumulative effects to fish populations are not anticipated.

Key:
CVP = Central Valley Project

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Chapter 15
Consultation, Coordination and Compliance

Introduction

Environmental Impact Statement (EIS) preparation involves public outreach and engagement with cooperating agencies, Native American Tribes and other interested parties. This chapter summarizes completed, ongoing, and anticipated efforts associated with the preparation of this EIS.

Consultation with the Public and Interested Parties

Consultation and outreach activities in support of this EIS initiated in mid-2015, with the release of the Notice of Intent (NOI), followed by a series of scoping meetings consistent with requirements of the National Environmental Policy Act (NEPA). This activity built upon previous outreach to the public, tribes, stakeholders (including hydropower generators and water users), and Federal and State agencies (engaged in the development of Environmental Assessments in 2003, 2012, 2013, 2015, and 2016), to cover annual flow augmentation in support of salmon health in the lower Klamath River during late summer. In addition, as described in Chapter 1, "Introduction," a number of stakeholders were engaged in the development of the *Draft Long-Term Plan for Protecting Late Summer Adult Salmon in the Lower Klamath River* (Reclamation 2015a), including the California Department of Fish and Wildlife (CDFW), California Water Impact Network, Hoopa Valley Tribe, Klamath Water Users Association, National Marine Fisheries Service (NMFS), San Luis & Delta-Mendota Water Authority (SLDMWA), Westlands Water District, Stillwater Sciences, Yurok Tribe and Northern California Power Agency.

Scoping Process

The scoping process was initiated on July 14, 2015, with publication of the NOI in the Federal Register, and continued through August 20, 2015.[1] During this period, U.S. Department of the Interior, Bureau of Reclamation (Reclamation) held scoping meetings, to inform the public and interested stakeholders about the project and to solicit comments and input on this EIS. These meetings were publicized via advertising, a news release, postcard notices, and the project website. Table 15-1 provides additional details on the public scoping meetings for this EIS.

[1] See *Scoping Report Long-Term Plan for Protecting Late Summer Adult Salmon in the Lower Klamath River*, Appendix A, for copy of NOI (Reclamation 2015b).

Table 15-1. EIS Scoping Meetings

Time/Date	Location	Attendance
5:30 to 7 p.m., August 5, 2015	Red Roof Inn 4975 Valley West Boulevard Arcata, California 95521	74
5:30 to 7 p.m., August 6, 2015	Trinity County Library 351 Main Street Weaverville, California 96093	13
5:30 to 7 p.m., August 11, 2015	Shilo Inn 2500 Almond Street Klamath Falls, Oregon 97601	28
5:30 to 7 p.m., August 12, 2015	Bureau of Reclamation, Mid-Pacific Regional Office Cafeteria Conference Rooms 1001 & 1002 2800 Cottage Way Sacramento, California 95825	11

Reclamation issued a news release on July 14, 2015, to media serving Arcata, Weaverville, and Sacramento, California, and Klamath Falls, Oregon,[2] announcing scheduled scoping meetings. In addition, Reclamation placed advertisements twice in each of the following papers: the Eureka, California-based *Times Standard* (ad runs July 29, 2015 and August 2, 2015); the Weaverville, California-based *Trinity Journal* (ad runs July 29, 2015 and August 5, 2015); and the Klamath Falls, Oregon-based *Herald & News* (ad runs August 4, 2015 and August 9, 2015).[3] Postcard notices were mailed on July 27, 2015 to 2,805 individuals and organizations on the mailing list for this EIS.[4]

The format for scoping meetings included an informal open house with poster stations staffed by Reclamation personnel. The format was designed to provide attendees an opportunity to review information about this EIS, ask questions, and have informal one-on-one discussions with staff. Each attendee was invited to sign in, and they were provided an information packet containing the meeting agenda, comment sheet and fact sheet.[5] A short presentation was held at each meeting to orient attendees to the overall project, the format of the meeting, and the process to provide written comments by mail or e-mail. Posters provided for attendee review included NEPA EIS process, scoping purpose, flow augmentation timeline, biology of potentially-affected fish species, hydrology of the affected regions, and potential environmental impacts and concerns.

In addition to the four public scoping meetings, tribal information meetings were held with the Klamath Tribes, Quartz Valley Tribe, Hoopa Valley Tribe, Resighini Rancheria, Yurok Tribe and Karuk Tribe. The same information and materials provided during the scoping meetings were presented at the tribal information meetings. Table 15-2 provides additional details for these tribal information meetings.

[2] See *Scoping Report on the Long-Term Plan for Protecting Late Summer Adult Salmon in the Lower Klamath River*, Appendix B, November 2015 for copy of news release (Reclamation 2015b).
[3] See *Scoping Report on the Long-Term Plan for Protecting Late Summer Adult Salmon in the Lower Klamath River*, Appendix C, November 2015 for copy of display advertisements (Reclamation 2015b).
[4] See *Scoping Report on the Long-Term Plan for Protecting Late Summer Adult Salmon in the Lower Klamath River*, Appendix D, November 2015 for copy of postcard notices (Reclamation 2015b).
[5] See *Scoping Report on the Long-Term Plan for Protecting Late Summer Adult Salmon in the Lower Klamath River*, Appendix E, November 2015 for copy of handout materials (Reclamation 2015b).

Table 15-2. EIS Tribal Information Meetings

Time/Date	Location	Attendance
1:30 p.m., October 5, 2015	Klamath Tribes Chiloquin, Oregon	6
9 a.m., October 6, 2015	Quartz Valley Tribe Fort Jones, California	3
1 p.m., October 7, 2015	Hoopa Valley Tribe Hoopa, California	3
1 p.m., October 12, 2015	Resighini Rancheria Klamath, California	8
10 a.m., October 13, 2015	Yurok Tribe Klamath, California	21
1:30 p.m., October 29, 2015	Karuk Tribe Conference Call	3

As summarized in the *Scoping Report on the Long-Term Plan for Protecting Late Summer Adult Salmon in the Lower Klamath River* (Reclamation 2015b), stakeholder input received during the scoping process was categorized into 13 areas:

- Purpose and Need
- Scope
- Alternatives Development
- Water Rights and Legal Authority
- Water Resources
- Biological Resources
- Tribal Trust Resources
- Environmental Justice
- Socioeconomic Resources
- Public Health
- Cumulative Impacts
- Global Climate
- Mitigation

A total of 112 comment documents, containing 338 comments, were received during the scoping period from agencies, organizations and individuals. Thirty-one comment documents were submitted at scoping meetings, 26 were mailed, 24 were e-mailed, and 21 were faxed. Three comment letters were received following tribal information meetings.

Public Websites

The Reclamation NEPA website provides the public and stakeholders with access to the scoping report, information distributed during the scoping process, and the contents of this EIS. Reclamation's NEPA web portal is located at:

http://www.usbr.gov/mp/nepa/nepa_projdetails.cfm?Project_ID=22021

The Klamath Basin Area Office (KBAO) website provides the public and stakeholders with access to copies of a preliminary version of the *Draft Long-Term Plan for Protecting Late Summer Adult Salmon in the Lower Klamath River* (December 2014), comments received on the December 2014 version, and the April 2015 *Draft Long-Term Plan for Protecting Late Summer Adult Salmon in the Lower Klamath River* (Reclamation 2015a). These documents are located on the KBAO website at:

http://www.usbr.gov/mp/kbao/programs/lt-plan.html

Cooperating Agency Involvement during Preparation of this EIS

Following release of the *Scoping Report on the Long-Term Plan for Protecting Late Summer Adult Salmon in the Lower Klamath River* (Reclamation 2015b), Reclamation—as the Federal lead agency—solicited interest among stakeholders and agencies to participate in preparation of this EIS, as a cooperating agency consistent with NEPA. Under NEPA, a cooperating agency is any agency, other than the lead agency, that has jurisdiction by law, or special expertise, with respect to any environmental impact involved in an action requiring an EIS. This solicitation included the six Federally-recognized tribes engaged during the scoping process, Federal and State agencies with applicable technical or regulatory responsibilities, and affected Central Valley Project water contractors. Stakeholders and agencies that requested and received cooperating agency status pursuant to NEPA include:

- U.S. Fish and Wildlife Service (USFWS)
- CDFW
- NMFS
- Bureau of Indian Affairs
- Humboldt County
- Hoopa Valley Tribe
- Karuk Tribe
- Klamath Tribes
- Yurok Tribe
- SLDMWA

Engagement with cooperating agencies for development of this EIS consisted of four, in-person meetings/workshops and two webinars. Each were designed to present data and receive cooperating agency feedback and advice for development of this EIS. Each cooperating agency

workshop was supported by a webinar to share information visually, and to support participation by agency representatives with travel restrictions. Cooperating agency engagement in development of this EIS is summarized in Table 15-3.

Table 15-3. EIS Cooperating Agency Engagement

Meeting	Date	Location	Milestone/Focus
Cooperating Agency Workshop Number 1	3/24/2016	Weaverville, California	• Convene cooperating agency members • Review and comment on measures identified during project scoping for accuracy and completeness; identify additional measures
Cooperating Agency Meeting: Central Valley Project Water Contractors	5/5/2016	Sacramento, California	• Discuss San Luis & Delta-Mendota Water Authority project alternative concepts
Cooperating Agency Workshop Number 2	5/10/2016	Redding, California	• Review and receive cooperating agency comments on proposed project actions • Identify and append proposed actions to conform, where applicable, to cooperating agency missions and requirements • Revisit and revise as necessary the schedule for cooperating agency workshops
Cooperating Agency Webinar: Developed Hydrology	6/8/2016	Sacramento, California	• Klamath River hydrology development and methodologies • Frequency of action analysis: preventive pulse and emergency flows • Integration of pulse flow frequency estimates into CalSim modeling
Cooperating Agency Workshop Number 3	7/25/2016	Redding, California	• Provide update on EIS schedule • Review alternatives development process and alternatives evaluated in EIS • Review modeling assumptions and receive comments on preliminary modeling results
Cooperating Agency Webinar: Administrative Draft EIS Review	9/6/2016	Sacramento, California	• Provide overview of Administrative Draft EIS, following its release for cooperating agency review and comment • Provide and discuss requested process for receipt of cooperating agency comments

Key:
EIS = Environmental Impact Statement

Next Steps in the Environmental Review Process

This Draft EIS will be released, for a 45-day period, to allow for public and agency review and comment. During this period, Reclamation will host an open house and public hearing pursuant to NEPA. The open house will occur during the first hour of the scheduled event. Following a brief presentation of the project and Draft EIS, attendees will be invited to visit and speak one-on-one, or in small groups, with project staff at poster stations set up in the meeting room.

Notification for the public hearing and availability of the Draft EIS will include release of the Notice of Availability (NOA) in the Federal Register, direct mail, and a news release, per NEPA requirements. The news release will be distributed to Reclamation's statewide VOCUS media database.

Following the close of the public comment period, Reclamation will review all agency and public comments in preparation for the Final EIS. When the Final EIS is complete, Reclamation will publish the document, and the NOA will be printed in the Federal Register, which will mark the start of a minimum 30-day waiting period before Reclamation issues its Record of Decision (ROD) on the project. In the ROD, which is the final step in the NEPA process, Reclamation will document its decision on which actions, if any, to take in order to address the purpose and need. It will also describe other risk-reduction plans it considered, identify any mitigation plans, and describe factors and comments taken into consideration when making its decision under NEPA.

Consultation with U.S. Fish and Wildlife Service and National Marine Fisheries Service

Endangered Species Act

The Federal Endangered Species Act (ESA), as amended, was enacted in 1973. The ESA applies to proposed Federal undertakings that are to be authorized, funded, or undertaken by a Federal agency and that may jeopardize the continued existence of any Federally-listed fish, wildlife, or plant species, or which may adversely modify or destroy designated critical habitat for such species. “Take” is defined under the ESA as, “To harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct” (16 United States Code (U.S.C.) Section 1532(19)). Under Federal regulations, “harm” is defined as, “An act which actually kills or injures wildlife.” This includes significant habitat modification or degradation where it actually results, or is reasonably expected to result, in death or injury to wildlife by substantially impairing essential behavioral patterns, including breeding, feeding, sheltering, spawning, rearing, and migrating (50 CFR sections 17.3, 222.102). “Harass” is defined similarly broadly. If there is a potential that implementing a project would result in take of a Federally-listed species, either a habitat conservation plan and incidental take permit (under Section 10(a) of the ESA), or a Federal interagency consultation (under Section 7 of the ESA), is required. The ESA also applies to private, State and local activities that may take a listed-species fish or wildlife species, but does not prohibit the take of listed plant species by these entities.

Under the ESA, NMFS has jurisdiction over anadromous fish, marine fish and reptiles, and most marine mammals; and the USFWS has jurisdiction over all other species, including all terrestrial and plant species, freshwater fish species, and a few marine mammals (such as the California sea otter). Listed species within the project area are described in Chapter 7, “Biological Resources – Fisheries,” and the Biological Resources – Terrestrial Technical Appendix.

Besides listing species within their respective jurisdictions as threatened or endangered, the issuing of incidental take permits, and conducting interagency consultations; NMFS and USFWS also are charged with designating “critical habitat” for threatened and endangered species. ESA defines critical habitat as: (1) specific areas within the geographical area occupied by the species at the time of listing, if they contain physical or biological features essential to a species’ conservation, and those features may require special management considerations or protection, and (2) specific areas outside the geographical area occupied by the species if the agency determines that the area itself is essential for conservation of the species (16 U.S.C. Section 1532(5)(A)). USFWS and NMFS also prepare recovery plans for the listed species.

In carrying out its obligations, Reclamation must consult with the appropriate regulatory agency or agencies (e.g., USFWS and NMFS) if the Federal undertaking is likely to affect a listed species or critical habitat. At the conclusion of this consultation process, those agencies render written statements (known as Biological Opinions) setting forth their opinion as to how an action being proposed by Reclamation would affect a listed species and its designated critical habitat.

Magnuson-Stevens Fishery Conservation and Management Act

The Magnuson-Stevens Fishery Conservation and Management Act, as amended by the Sustainable Fisheries Act (Public Law 104-297), requires that all Federal agencies consult with NMFS on activities or proposed activities authorized, funded, or undertaken by that agency that may adversely affect Essential Fish Habitat (EFH) for commercially managed marine and anadromous fish species. EFH includes specifically identified waters and substrate necessary for fish spawning, breeding, feeding, or growing to maturity. EFH also includes all habitats necessary to allow the production of commercially valuable aquatic species, to support a long-term sustainable fishery, and to contribute to a healthy ecosystem (16 U.S.C. Section 1802(10)).

Marine Mammal Protection Act

The Marine Mammal Protection Act (MMPA) was enacted in 1972. All marine mammals are protected under the MMPA. The MMPA prohibits, with certain exceptions, the “take” of marine mammals in U.S. waters and by U.S. citizens on the high seas, and the importation of marine mammals and marine mammal products into the United States. It defines “take” to mean “to hunt harass, capture, or kill” any marine mammal or attempt to do so. Exceptions to the moratorium can be made through permitting actions for take incidental to commercial fishing and other non-fishing activities; for scientific research; and for public display at licensed institutions such as aquaria and science centers.

Consultation with Tribal Governments

Consistent with President Clinton’s April 29, 1994 Memorandum, and President Obama’s November 5, 2009 Memorandum, Reclamation engaged six Federally-recognized tribal governments to participate in preparation of this EIS. Reclamation met with tribes in California and Oregon in 2015, to, in part, solicit their participation in this EIS as cooperating agencies. Tribes contacted were Klamath Tribes, Quartz Valley Tribe, Hoopa Valley Tribe, Resighini Rancheria, Yurok Tribe and Karuk Tribe. Tribes with specialized technical resources, consistent with NEPA criteria for cooperating agency status, were invited to join the project as cooperating agencies. Native American tribes that accepted the invitation as cooperating agencies include the Klamath Tribes, Hoopa Valley Tribe, Yurok Tribe and Karuk Tribe.

Reclamation will continue to consult with each tribe on a government-to-government basis before taking any action that could affect a tribal government. Under the Federal Trust responsibility, Reclamation will provide full disclosure of the beneficial and adverse impacts of a project to the tribal government in a manner that provides adequate time for review and response. Reclamation will review comments received, and consult with the tribal government prior to decisions related to a project.

Tribes and Indian Trust Assets were considered during preparation of this EIS, in accordance with environmental justice considerations identified in Executive Order 12898 (February 11, 1994), as summarized in Chapter 13, "Indian Trust Assets," and Chapter 14, "Environmental Justice."

References

Reclamation (U.S. Department of the Interior, Bureau of Reclamation). 2015a. Draft Long-Term Plan for Protecting Late Summer Adult Salmon in the Lower Klamath River. April.

____. 2015b. Scoping Report on the Long-Term Plan for Protecting Late Summer Adult Salmon in the Lower Klamath River. Humboldt County, California. November.

Chapter 16
Distribution of Draft EIS

Introduction

This chapter provides locations where the Draft Environmental Impact Statement (EIS) is available for review and a list of the governmental entities, organizations, and interested parties that received copies of this Draft EIS.

Document Availability

The public distribution of this Draft EIS emphasized the use of electronic media to ensure cost-effective, broad availability to the public and interested parties. This Draft EIS is available for viewing on the U.S. Department of the Interior, Bureau of Reclamation website at http://www.usbr.gov/mp/nepa/nepa_projdetails.cfm?Project_ID=22021.

An electronic copy of the Draft EIS is available for review at the following locations:

U.S. Department of the Interior, Bureau of Reclamation Library
2800 Cottage Way
Sacramento, California 95825

Bureau of Reclamation, Northern California Area Office
16349 Shasta Dam Boulevard
Shasta Lake, California 96019

Chiloquin Branch Library
104 South 1st Avenue
Chiloquin, Oregon 97624

Humboldt County Library
1313 3rd Street
Eureka, California 95501

Klamath County Library
126 South 3rd Street
Klamath Falls, Oregon 97601

Los Banos Public Library
1312 South 7th Street
Los Banos, California 93635

Shasta County Public Library
Redding Library
1100 Parkview Avenue
Redding, California 96001

Trinity County Library
351 Main Street
Weaverville, California 96093

Trinity River Restoration Program
1313 Main Street
Weaverville, California 96093

Distribution List

Over 2,800 individuals, agencies, and organizations were informed by e-mail or mail of the availability of, and locations to obtain, the Draft EIS.

Parties listed below received an electronic copy of this Draft EIS.

Federal Agencies

- U.S. Department of Commerce, National Marine Fisheries Service
- U.S. Department of the Interior, Bureau of Indian Affairs
- U.S. Department of the Interior, Fish and Wildlife Service
- U.S. Environmental Protection Agency

State Agencies

- California Department of Fish and Wildlife
- State Water Resources Control Board

Regional and Local Entities

- Humboldt County
- San Luis & Delta-Mendota Water Authority

Tribal Interests

- Hoopa Valley Tribe
- Karuk Tribe
- Klamath Tribes
- Yurok Tribe

Chapter 17
List of Preparers

Several agency and consultant staff were involved in the review of the Draft Environmental Impact Statement. Following is a list of persons who were primarily responsible for preparing sections of the Environmental Impact Statement (40 CFR 1502.17).

Reclamation (NEPA Lead Agency)		
Name	**Qualifications**	**Participation**
Julia Long	B.S., Natural Resources Management; 15 years of experience.	Project Manager; NEPA
Charlie Chamberlain	B.S., Agricultural Science; 19 years of experience.	Biological Resources
Russ Grimes	B.A., Environmental Studies; M.S., Environmental Management; 26 years of experience.	NEPA Sufficiency
Tom Kisanuki	B.S., Wildlife and Fisheries Biology; M.S., Natural Resources; 36 years of experience.	Biological Resources
Andrea Meier	B.S., Environmental Toxicology; Master of Public Policy and Administration; 14 years of experience.	NEPA Process
Nancy Parker	B.S., Systems Science Engineering; 26 years of experience.	Water Resources Modeling, Surface Water Supply and Management
Paul Zedonis	B.S., Biology; M.S., Fisheries Management; 25 years of experience.	Alternatives Development
MWH		
Name	**Qualifications**	**Participation**
Mary Paasch, P.E., PMP	B.S., Agricultural Engineering; M.S., Agricultural Engineering; 21 years of experience.	Project Manager, Alternatives Development
Rina Binder-Macleod	B.Eng., Environmental Engineering; M.Eng., Civil Engineering; 4 years of experience.	Project Coordinator
Matt Bachman	B.S., Civil and Environmental Engineering; M.S., Water Science and Policy; 4 years of experience.	Water Resources Modeling, Hydropower Generation
Vincent Barbara	B.S., Agriculture Business; M.A., Economics; 8 years of experience.	Agricultural Resources, Socioeconomics
Ian Buck, P.E., PMP	B.S., Civil Engineering; 5 years of experience.	Water Resources Planning
Tom FitzHugh	B.A., Political Science; M.S., Geographic Information Systems; 20 years of experience.	Water Resources Modeling, Surface Water Quality

MWH		
Name	**Qualifications**	**Participation**
Cindy Jones	B.S., Biology; M.S., Environmental Studies/Science and Biological Sciences; 23 years of experience.	Biological Resources
Hugh Klein, P.G.	B.A., Geology; M.S., Engineering; M.S., Geology; 30 years of experience.	Groundwater Resources/Groundwater Quality
Barbara McDonnell	B.A., Biology; M.A., Biology; 44 years of experience.	NEPA
Craig Moyle, PMP	B.A., Journalism; 24 years of experience.	Public and Stakeholder Outreach
Danelle Pecot, P.E., PMP	B.S., Civil Engineering; M.S., Civil Engineering; 8 years of experience.	Alternatives Development
Meredith Parkin, PMP	B.S, Human Nutrition and Food Science; J.D., Law; 21 years of experience.	NEPA, Environmental Justice
Jeff Payne, P.E.	B.S., Civil Engineering; M.S., Civil and Environmental Engineering; 17 years of experience.	Water Resources Planning
William Smith, P.E.	B.S., Forest Engineering; 40 years of experience.	Water Resources Modeling, Surface Water Supply and Management, Surface Water Quality, Hydropower Generation
Stephanie Theis	B.S., Fisheries Ecology; Graduate Studies, Applied Ecology and Conservation Biology; 26 years of experience.	Biological Resources – Fisheries, Tribal Trust Resources
Ascent Environmental (Under subcontract to MWH)		
Name	**Qualifications**	**Participation**
Dimitri Antoniou	B.S., Environmental Management and Protection; M.S., City and Regional Planning; 6 years of experience.	Air Quality and Greenhouse Gas
Honey Walters	B.S., Environmental Science and Chemistry; M.S., Atmospheric Science; 16 years of experience.	Air Quality and Greenhouse Gas
Cramer Fish Science (Under subcontract to MWH)		
Name	**Qualifications**	**Participation**
Brad Cavallo	B.S., Fisheries Biology; M.S., Aquatic Ecology; 22 years of experience.	Fisheries Lifecycle Modeling
North State Resources (Under subcontract to MWH)		
Name	**Qualifications**	**Participation**
Len Lindstrand III	B.S., Wildlife Management; Minors in Fisheries Management and Forestry; 24 years of experience.	Biological Resources – Terrestrial

North State Resources (NSR) (Under subcontract to MWH)		
Name	**Qualifications**	**Participation**
Bruce Webb	B.A., Psychology; Certified Environmental Planner; 44 years of experience.	Biological Resources – Terrestrial
Keith Marine	B.S., Wildlife and Fisheries Biology; M.S., Ecology; 33 years of experience.	Biological Resources – Fisheries
Watercourse Engineering (Under subcontract to MWH)		
Name	**Qualifications**	**Participation**
Mike Deas, P.E.	B.S., Civil Engineering; M.S., Civil and Environmental Engineering; PhD, Civil and Environmental Engineering; 30 years of experience.	Surface Water Supply and Management, Surface Water Quality
Edwin Limanto	B.S., Civil Engineering; M.S., Civil and Environmental Engineering; 10 years of experience.	Surface Water Supply and Management, Surface Water Quality
I.E. Sogutlugil	B.S., Civil Engineering; M.S., Civil and Environmental Engineering; 14 years of experience.	Surface Water Supply and Management, Surface Water Quality
Westwater Research (Under subcontract to MWH)		
Name	**Qualifications**	**Participation**
Harry Seely	B.S., Economics; M.S., Natural Resources and Agricultural Economics; 23 years of experience	Agricultural Economics

Key:
BA = Bachelor of Arts
B.Eng. = Bachelor of Engineering
B.S. = Bachelor of Science
M.A. = Master of Arts
M.Eng = Master of Engineering
M.S. = Master of Science
NEPA = National Environmental Policy Act
PE = Professional Engineer
P.G. = Professional Geologist
PMP = Project Management Professional
Reclamation = U.S. Department of the Interior, Bureau of Reclamation

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U.S. Department of the Interior
Bureau of Reclamation

RECLAMATION

Managing Water in the West

Environmental Impact Statement Glossary Appendix

Long-Term Plan to Protect Adult Salmon in the Lower Klamath River
Draft

October 2016

Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

Glossary

The definitions in this glossary include technical and regulatory terms used in the Long Term Plan to Protect Adult Salmon in the Lower Klamath River (LTP) Environmental Impact Statement (EIS). Some of the definitions of terms were specifically developed for the LTP EIS and may not be the same as definitions used for other programs in other places.

Term	Definition
acre-foot	The volume of water that would cover 1 acre to a depth of 1 foot, or 325,851 gallons of water. A flow of 1 cubic foot per second (cfs) for 1 day is approximately 2 acre-feet.
adaptive management	Systematic approach for improving resource management by learning from management outcomes.
adjudication	A process by which the comprehensive determination of all water rights in a stream system is made. In California, statutory adjudication happens if a claimant petitions the California State Water Resources Control Board (SWRCB) for an adjudication and the SWRCB finds the action necessary and in the public interest. The California Supreme Court has held that claimants or petitioners can include not only water users, but also those seeking recognition of public trust values on a streamwide basis.
affect/effect	To affect (a verb) is to bring about a change. An effect (usually a noun) is the result of an action.
affected environment	Existing biological, physical, social, and economic conditions of an area subject to change, both directly and indirectly, as a result of a proposed human action.
afterbay	A pool of water at the base of a dam; specifically, water after it has passed through a turbine.
air quality	Measure of the health-related and visual characteristics of the air, often derived from quantitative measurements of the concentrations of specific injurious or contaminating substances.
alevin	The life stage of a salmon between hatching from the egg and emergence from the stream gravels as a fry. Alevins are characterized by the presence of a yolk sac, which provides nutrition while the alevin develops in the redd.
alluvial	Deposition of sediment over a long period of time by a river; an alluvial layer; pertaining to the soil deposited by a stream.
alluvium	Soil particles transported and deposited by water.
alternatives	Courses of action that may meet the objectives of a proposed action at varying levels, including the most likely future without the project or action. An Environmental Assessment (EA) or an Environmental Impact Statement (EIS) identifies and objectively evaluates and analyzes all reasonable alternatives, including a no-action alternative.
ammocoete	Lamprey larva.
anadromous fish	Fish such as salmon or steelhead trout that hatch in fresh water, migrate to and mature in the ocean, and return to fresh water as adults to spawn.
anoxic conditions	Conditions with a deficiency of oxygen.
appropriative water rights	Water rights based on the principle of prior appropriations, or “first in time, first in right.”
aquatic	Living or growing in or on the water.
aquifer	An underground geologic formation of permeable rock that stores, transmits, and yields significant quantities of groundwater to wells and springs.
beneficial use	The uses of a water resource that are protected by state water quality standards. Beneficial uses include human consumption, aquatic life, recreation, and fish and wildlife habitat.

Glossary

Term	Definition
biodiversity	The variety of life and its processes, including the variety of living organisms, the genetic differences among them, and the communities and ecosystems in which they occur.
Biological Assessment (BA)	A document prepared for the Section 7 process under the Federal Endangered Species Act (ESA) of 1993, as amended, to determine whether a proposed major construction activity under the authority of a Federal action agency is likely to adversely affect listed species, proposed species, or designated critical habitat.
Biological Opinion (BO)	Document issued under the authority of the Federal ESA stating the U.S. Fish and Wildlife Service (USFWS) and/or the National Marine Fisheries Service (NMFS) finding as to whether a Federal action is likely to jeopardize the continued existence of a threatened or endangered species or result in the destruction or adverse modification of critical habitat.
blue-green algae	Algae that can cause problems in aquatic environments because some produce chemicals that are toxic to animals, including humans.
broodstock	Mature fish species used for breeding in hatcheries.
CalSim II model	A planning model designed to simulate the operations of the Central Valley Project (CVP) and State Water Project (SWP) reservoir and water delivery system under current and future conditions. CalSim-II is a specific application of the Water Resources Integrated Modeling System (WRIMS) to Central Valley water operations CalSim predicts how reservoir storage and river flows would be affected based on changes in system operations. CalSim output is typically used to help assess impacts on water supply, water quality, aquatic resources, and recreation.
candidate species	Any species undergoing status review by the U.S. Secretary of the Interior or U.S. Secretary of Commerce for listing as an endangered or a threatened species but not yet the subject of a proposed rule (see 50 Code of Federal Regulations (CFR) 424.02), or any species accepted as a candidate species by the California Fish and Game Commission pursuant to Fish and Game Code Section 2074.2.
carryover storage	Water remaining in storage in a reservoir or lake at the end of a water year.
catch	Within a recreational fishery area, refers to the number of fish captured.
census	A compilation of data on an aspect of the U.S. people and/or economy provided by the U.S. Bureau of the Census.
Central Valley Project (CVP)	Federally operated water management and conveyance system that provides water to agricultural, urban, and industrial users in California as defined by Section 3403(d) of the Central Valley Project Improvement Act (CVPIA), “all Federal reclamation projects located within or diverting water from or to the watershed of the Sacramento and San Joaquin rivers and their tributaries as authorized by the Act of August 26, 1937 (50 Stat. 850) and all Acts amendatory or supplemental thereto, ...”
Central Valley Project Improvement Act (CVPIA)	Public Law 102-575, Title 34. The CVPIA was signed into law by the President in October 1992. The CVPIA mandates major changes in management of the CVP particularly for the protection, restoration, and enhancement of fish and wildlife. Responsibilities for implementing the CVPIA are shared by the U.S. Department of the Interior, Bureau of Reclamation (Reclamation), and USFWS. The CVPIA puts fish and wildlife on an equal footing with agricultural, municipal, industrial, and hydropower users.
Central Valley Project water service contractor	Water users who have contracted with Reclamation for water developed by and conveyed through CVP facilities.
channel	Natural or artificial watercourse, with a definite bed and banks to confine and conduct continuously or periodically flowing water.
cohort	A group of fish spawned during a given period, usually within a year.
conference	The interagency cooperation process required for a Federal action that is likely to jeopardize the continued existence of a species proposed for listing, or result in the destruction or adverse modification of proposed critical habitat.
confined aquifer	An aquifer bounded above and below by impermeable or confining layers of distinctly lower permeability than the aquifer itself.
confluence	The meeting of two or more bodies of water, such as the point where a tributary joins the mainstem.

Term	Definition
conjunctive use	The planned use of groundwater in conjunction with surface water in overall management to optimize water resources.
conservation	Actions taken to minimize or compensate for project effects on ecosystem resources or to benefit or promote the recovery of listed species as an integral part of a proposed action
consultation	The process required of a Federal agency when any activity authorized, carried out, or conducted by that agency may affect a listed species or designated critical habitat; consultation is with USFWS or NMFS and may be either informal or formal.
contaminants	Any undesirable physical, chemical, biological, or radiological substance present in water as a result of human activities.
conveyance	The movement or transportation of water from one location to another location through various water transportation systems, such as canals, sloughs, channels, pipelines, ditches, etc.
cooperating agency	Under NEPA, the agencies having responsibility to assist the lead agency by participating in the NEPA process. The role of the cooperating agencies may include conducting environmental analyses of resources which the cooperating agency has jurisdiction by law or special expertise.
critical habitat	A description of the specific areas with physical or biological features essential to the conservation of a listed species and that may require special management considerations or protection. These areas have been legally designated via Federal Register notices.
cubic feet per second (cfs)	A measure of the volume rate of water movement. As a rate of stream flow, a cubic foot of water passing a reference section in 1 second of time. One cubic foot per second equals 0.0283 meters per second (7.48 gallons per minute). One cubic foot per second flowing for 24 hours produces approximately 2 acre-feet.
cumulative effect - ESA	Those effects of future non-Federal activities that are reasonably certain to occur within the action area of a Federal action subject to consultation.
cumulative effect – NEPA	For the NEPA, Federal regulations (40 CFR 1508.7) define cumulative effects as those effects that result from incremental impacts of a proposed action when added to other past, present, and reasonably foreseeable future actions, regardless of which agency (Federal or non-Federal) or person undertakes such actions. Cumulative effects can result from individually minor but collectively significant actions that take place over time.
cyanobacteria	Photosynthetic bacteria, also known as blue-green algae. Cyanobacteria form extensive and highly visible blooms in the freshwater and marine environment.
dead pool	Dead pool refers to water in a reservoir that cannot be drained by gravity through a dam's outlet works.
Decision-1641 (D-1641)	State Water Resources Control Board Water Right Decision (March 2000) that implemented the 1995 Bay-Delta Water Quality Control Plan.
delta	A low, nearly flat alluvial tract of land formed by deposits at or near the mouth of a river. In this report, “Delta” refers to the delta formed by the Sacramento and San Joaquin Rivers.
density	The mass of a substance per unit of volume of that substance (i.e., the density of water changes with changes in temperature).
direct effects	Related to socioeconomics, they are one or a series of production changes or expenditures made by producers/consumers as a result of an activity or policy. These initial changes are determined by an analyst to be a result of this activity or policy. Applying these initial changes to the multipliers in an IMPLAN model will then display how the region will respond, economically to these initial changes.
dissolved oxygen (DO)	A commonly employed measure of water quality. The concentration of free (not chemically combined) molecular oxygen (a gas) dissolved in water, usually expressed in milligrams per liter, parts per million, or percent of saturation. DO levels are considered the most important and commonly employed measurement of water quality and indicator of a water body's ability to support desirable aquatic life.

Term	Definition
distinct population segment (DPS)	A subdivision of a vertebrate species that is treated as a species for purposes of listing under the Federal ESA. To be so recognized, a potential distinct population segment must satisfy standards specified in a USFWS or NMFS policy statement (see the February 7, 1996, Federal Register, pages 4,722-4,725). DPS standards require a DPS to be separable from the remainder of, and significant to, the species to which it belongs.
diversion	The act of taking water out of a river system or changing the flow of water in a system for use in another location.
drawdown	Lowering of the water level in a reservoir.
ecosystem	An interactive system that includes the organisms of a natural community association together with their abiotic physical, chemical, and geochemical environment.
electrical conductivity (EC)	The measurement of a materials ability to conduct an electrical current. Used as a surrogate measurement for salinity.
elevation	Elevation in feet above mean sea level (msl).
emergent	Flooded or ponded areas that support rooted, herbaceous vegetation with parts of the shoot both below and above water.
emergent vegetation	Aquatic plants rooted underwater that grow above (emerge from) the surface of the water (e.g., cattails).
employment (jobs)	Employment in IMPLAN is measured in number of jobs. A job is the annual average of monthly jobs in that industry (this is the same definition used by Quarterly Census of Employment Wages, Bureau of Labor Statistics, and Bureau of Economic Analysis nationally). Thus, 1 job lasting 12 months = 2 jobs lasting 6 months each = 3 jobs lasting 4 months each. A job can be either full-time or part-time.
endangered species	Any species or subspecies of bird, mammal, fish, amphibian reptile, or plant that is in serious danger of becoming extinct throughout all or a significant portion of its range.
Endangered Species Act (ESA) consultation	In compliance with the Federal ESA, the process by which a Federal agency presents information to the USFWS or National Oceanic and Atmospheric Administration (NOAA) Fisheries Service regarding actions that may affect listed species or their designated habitat.
Endangered Species Act (ESA) of 1973, as Amended	Federal legislation that is intended to provide a means to conserve the ecosystems upon which endangered and threatened species depend, and to provide programs for the conservation of those species, thus preventing extinction of plants and animals. The law is administered by the USFWS (U.S. Department of the Interior) and NMFS (U.S. Department of Commerce), depending on the species. Some relevant sections are as follows:
	§ Section 4 Part – Addresses the listing and recovery of species and designation of critical habitat.
	§ Section 6 Part – Focuses on cooperation with the States and that authorizes USFWS and NMFS to provide financial assistance to States that have entered into cooperative agreements supporting the conservation of endangered and threatened species.
	§ Section 7 Part – Requires all Federal agencies, in consultation with USFWS or NMFS, to use their authorities to further the purpose of the Federal ESA and to ensure that their actions are not likely to jeopardize the continued existence of listed species or result in destruction or adverse modification of critical habitat.
	§ Section 9 Part – Part Defines prohibited actions, including the import and export, take, possession of illegally taken species, transport, or sale of endangered or threatened species.
	§ Section 10 – Lays out the guidelines under which a permit may be issued to authorize prohibited activities, such as take of endangered or threatened species.
	§ Section 10(a)(1)(A) – Allows for permits for the taking of threatened or endangered species for scientific purposes or for purposes of enhancement of propagation or survival.
	§ Section 10(a)(1)(B) – Allows for permits for incidental taking of threatened or endangered species.

Term	Definition
endemic	Native to or confined to a certain region.
environmental consequences	For a project, the impacts to the affected environment that are expected from implementation of a given alternative.
Environmental Impact Statement (EIS)	An analysis required by the NEPA for all major Federal actions that evaluates the environmental risks of alternative actions.
environmentally preferable alternative	The alternative that will promote the national environmental policy as expressed in NEPA. Ordinarily, this means the alternative that causes the least damage to the biological and physical environment; it also means the alternative which best protects, preserves, and enhances historic, cultural, and natural resources.
Essential Fish Habitat (EFH)	Waters and substrate necessary for fish to spawn, breed, feed, or grow to maturity. Fish covered under Essential Fish Habitat include Pacific salmon and commercially valuable estuarine and marine fish species.
escapement (of fish)	That portion of an anadromous fish population that escapes the commercial and recreational fisheries and reaches the freshwater spawning grounds.
estuary	A partly enclosed coastal body of water with one or more rivers or streams flowing into it, and with a free connection to the open sea.
estuary area	Transition area between the land and ocean. The area is exposed to tides, waves, and wind but is partially protected by the surrounding land.
eutrophic	Waters rich in dissolved nutrients (especially nitrogen and phosphorus); leads to accelerated growth of algae and plants that depletes oxygen levels.
eutrophication	The degradation of water quality as a result of enrichment by nutrients, primarily nitrogen and phosphorus, which in turn results in excessive plant (principally algae) growth and decay.
evaporation	The change of a substance from the liquid phase to the gaseous (vapor) phase.
Evolutionarily Significant Unit (ESU)	A population or group of populations that is considered distinct (and hence a “species”) for purposes of conservation under the Federal ESA. To qualify as an ESU, a population must (1) be reproductively isolated from other conspecific populations, and (2) represent an important component in the evolutionary legacy of the biological species.
export	Water diversion from the Delta used for purposes outside the Delta.
extinct species	A species that no longer exists. For the Federal ESA, a species currently believed to be extinct.
fallowed land	Cultivated land that lies idle during a growing season.
Federal Register	The official daily publication for Rules, Proposed Rules, and Notices of Federal agencies and organizations, as well as Executive Orders and other presidential documents.
fish die-off	A fish die-off is determined by the magnitude and speed at which the population is affected – smaller returning populations can have fewer dead fish and still be classified as a fish die-off. However, returning populations are not always known. For the LTP EIS, classifying a fish die-off will depend on multiple factors, including fish population size, fish density, and other factors deemed critical by Reclamation and the LTP Technical Team.
fish ladder (fishway, fish passageway)	A structure on or around artificial barriers such as dams and locks to allow fish to move around the barrier during migration.
fisheries	A season or industry of commercial or sport fishing.
fishery	A community of fish and their habitat.
Flavobacter columnare (Columnaris)	A species of bacteria that causes the Columnaris disease, which infects freshwater fish.
flood storage reservation	The storage in a reservoir used to reduce the river’s flow downstream in a flood event.
floodplain	Part of a river valley composed of unconsolidated, river-borne sediment that is periodically flooded.
floodway	The channel of a river or other watercourse and adjacent land areas that convey flood waters.

Term	Definition
flow	The volume of water passing a given point per unit of time.
	Instream Flow Requirements – Amount of water flow in a stream course required to sustain instream values.
	Minimum Flow – Lowest flow in a specified time period.
	Peak Flow – Maximum instantaneous flow in a specified time period.
	Return Flow – Portion of water previously diverted from a stream and subsequently returned to that stream or to another body of water.
focal species	Species of ecological and/or human value that is of priority interest for study or management.
forebay	Water stored behind a dam; specifically, water intended to go through a turbine.
fragmentation of habitat	Division of a large piece of habitat into a number of smaller, isolated patches that typically have substantially less ecological value than the contiguous habitat.
fry	Fry are young fish that have absorbed their yolk sac and emerged from the redd. They typically use low velocity, shallow habitats near the river banks. In the Central Valley, salmon fry are frequently defined as juveniles smaller than 50 millimeters in fork length.
Fully Protected species	The classification of Fully Protected was the State's initial effort in the 1960s to identify and provide additional protection to those animals that were rare or faced possible extinction. Lists were created for fish, mammals, amphibians and reptiles, birds and mammals. Please note that most fully protected species have also been listed as threatened or endangered species under the more recent endangered species laws and regulations. Fully Protected species may not be taken or possessed at any time and no licenses or permits may be issued for their take except for collecting these species for necessary scientific research and relocation of the bird species for the protection of livestock.
geographic information system (GIS)	A computer system that allows for input and manipulation of geographic data to allow researchers to manipulate, analyze, and display the information in a map format.
greenhouse gases (GHGs)	Gases including carbon dioxide, methane, and nitrous oxide that prevent heat from escaping from the atmosphere, resulting in climate change (also known as global warming).
groundwater	Any water naturally stored underground in aquifers, or that flows through and saturates soil and rock, supplying springs and wells.
groundwater level	Refers to the water level in a well, and is defined as a measure of the hydraulic head in the aquifer system.
groundwater management	The planned and coordinated management of a groundwater basin or portion of a groundwater basin with a long-term sustainability of the resource.
groundwater overdraft	A condition of a groundwater basin in which the amount of water withdrawn by pumping exceeds the amount of water that recharges the basin over a period of years, during which water supply conditions approximate average.
groundwater pumping	Quantity of water extracted from groundwater storage.
groundwater storage	The quantity of water in the zone of saturation.
habitat	The specific places where the environmental conditions (i.e., physical and biological conditions) are present that are required to support occupancy by individuals or populations of a given species.
hangover effect	A hypothesized theory in which background levels of *Ichthyophthirius multifiliis* (Ich) are elevated in the year following an outbreak leading to greater probability of another outbreak occurring with increased severity resulting in greater fish kill risk.
harm	An act that actually kills or injures wildlife. Such an act may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns including breeding, feeding, or sheltering (50 CFR 17.3).
hatchery	A place where large numbers of fish eggs are artificially fertilized and fry are hatched in an enclosed environment.
heavy metals	A metal of atomic weight greater than 23 that forms soaps on reaction with fatty acids. Examples are aluminum, lead, cobalt.

Term	Definition
herbaceous	Referring to a plant that has leaves and stems that die down at the end of the growing season to the soil level. They have no persistent woody stem above ground.
herpetofauna	Reptiles and amphibians of a specific region, habitat, or geological period.
histopathology	The study of changes in tissues caused by disease.
human environment	The natural and physical environment and the relationship of people with that environment.
hydrograph	A chart or graph showing the change in flow over time for a particular stream or river.
hypereutrophic	Very nutrient-rich lakes characterized by frequent and severe nuisance algal blooms and low transparency.
hypolimnion	The bottom, and most dense, layer of a stratified lake. It is typically the coldest layer in the summer and warmest in the winter. It is isolated from wind mixing and typically too dark for much plant photosynthesis to occur.
Ichthyophthirius multifiliis (Ich)	An endemic protozoan pathogen of freshwater fish, including anadromous populations of salmonids. The Ich pathogen is common in aquaculture and aquarium trade.
IMPLAN®	IMpact Analysis for PLANning, a regional input-output model that evaluates regional economic effects.
incidental take	Take of listed fish or wildlife species that results from, but is not the purpose of, carrying out an otherwise lawful activity conducted by a Federal agency or applicant.
Incidental Take Permit – Federal	Federal exception to Section 9 of the Federal ESA (16 USCA 1538); a permit issued pursuant to Section 10 of the Federal ESA (16 USCA 1539(a)(1)(B)).
indirect effect	An effect caused by an action that takes place later in time than the action, but is still reasonably certain to occur.
induced effects	Related to socioeconomics, they represent the response by an economy to an initial change that occurs through re-spending of income received by a component of value added (employee). The labor income is recirculated through the household spending patterns causing further local economic activity.
infectivity	The ability of a pathogen to establish an infection and the frequency at which the pathogen spreads from the host.
intake structure	Facility designed to divert water from the river or reservoir.
interest group	An agency or other entity that has expressed an interest, verbally or in writing, in becoming more involved in the development of a planned project.
invertebrate	Animals without backbones such as aquatic insects, worms, clams, and snails.
irrigation water	Water used primarily in the production of agricultural crops or livestock, including domestic use incidental thereto, and the watering of livestock. Irrigation water does not include water used for domestic uses, such as watering landscaping or pasture for animals (e.g., horses) that are kept for personal enjoyment. It generally applies only to landholdings greater than 2 acres.
jeopardize the continued existence of	To engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species.
juvenile	Young fish not having reached reproductive age. For anadromous salmonids, young fish are generally considered juveniles once they are greater than 50 millimeters in length.
Klamath Hydroelectric Project	A system of hydroelectric components that includes the dams, powerhouses, and other facilities for generation of hydroelectric power on the Klamath River and developed jointly by Reclamation and the California-Oregon Power Company (COPCO, the predecessor to PacifiCorp).
Klamath River Basin	The portion of land drained by the Klamath River and its tributaries. The Klamath River Basin is divided into the Upper Klamath Basin and the Lower Klamath Basin.
labor income	All forms of employment income, including Employee Compensation (wages and benefits) and Proprietor Income.
land cover type	The dominant features of the land surface. A land cover type can be defined by natural vegetation, water, or human uses (e.g., agricultural lands, landscaping).

Term	Definition
land retirement	Permanent or long-term removal of land from agricultural production.
lead agency	The government agency that has the principal responsibility for carrying out or approving a project and therefore the principal responsibility for preparing NEPA documents. For the LTP EIS, Reclamation is the Federal lead agency under NEPA.
Level 2 (L-2) Refuge Water Supply	The minimum supply of water required at certain Federal, State, and private refuges for basic development and management of suitable habitat conditions for migrating waterfowl and wildlife pursuant to CVPIA Public Law 102-575, Title 34, Section 3406 (d)(1); measured in acre-feet of water. Level 2 (L-2) Water is water provided from the CVP yield and non-project water (existing water rights, entitlement water).
Level 4 (L-4) Refuge Water Supply	The full amount of water required at certain Federal, State, and private wildlife refuges for optimum development and management of suitable habitat conditions for migrating waterfowl and wildlife, pursuant to CVPIA Public Law 102-575, Title 34, Section 3406 (d)(2); measured in acre-feet of water.
listed species	Any species of fish, wildlife, or plant that has been determined to be endangered or threatened under Section 4 of the Federal ESA of 1993, as amended.
listing	The formal process through which USFWS or NMFS adds species to the Federal list of endangered and threatened wildlife and plants.
Lower Klamath Basin	The portion of the Klamath River Basin downstream of Iron Gate Dam.
lower Klamath River	The portion of the Klamath River from the confluence with the Trinity River to the Pacific Ocean.
LTP Technical Team	For the purpose of this EIS, the team of Federal, State, and tribal resource specialists, including fisheries biologists or pathologists, providing technical guidance.
mainstem	The principal river in a basin, as opposed to the tributary streams and smaller rivers that feed into it.
mean sea level (msl)	The average height of the sea's surface over a long period.
Memorandum of Understanding (MOU)	A means of gaining formal consensus between two or more parties on a particular complex issue.
microcystin	A toxin produced by the blue-green algal species *Microcystis aeruginosa*.
mitigation	To moderate, reduce, or alleviate the impacts of a proposed activity; includes, in order, (1) avoiding the impact by not taking a certain action or parts of an action; (2) minimizing impacts by limiting the degree or magnitude of the action and its implementation; (3) rectifying the impact by repairing, rehabilitating, or restoring the affected environment; (4) reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action; and (5) compensating for the impact by replacing or providing substitute resources or environments.
model	A tool used to mathematically represent a process that could be based on empirical or mathematical functions. Models can be computer programs, spreadsheets, or statistical analyses.
National Ambient Air Quality Standards (NAAQS)	The U.S. Environmental Protection Agency sets National Ambient Air Quality Standards (NAAQS), as required by the Clean Air Act as amended in 1990, for pollutants considered harmful to public health or the environment. NAAQS are in place for six pollutants: carbon monoxide, lead, nitrogen dioxide, ozone, particulate matter, and sulfur dioxide.
National Environmental Policy Act (NEPA)	Federal legislation establishing the national policy that environmental impacts will be evaluated as an integral part of any major Federal action. Requires the preparation of an EIS for all major Federal actions significantly affecting the quality of the human environment.
National Wildlife Refuge (NWR)	A refuge managed by the USFWS.
nonnative species	Botanical, wildlife, and aquatic species that originate elsewhere and are brought into a new area, where they may dominate the local species or in some way negatively affect the environment for native species.

Term	Definition
nonpoint source pollution	A term in the Clean Water Act also called “polluted runoff,” water pollution produced by diffuse land-use activities. Occurs when runoff carries fertilizer, animal wastes, and other pollution into rivers, streams, lakes, reservoirs, and other bodies of water.
noxious weed	An alien, introduced or exotic undesirable plant species that outcompetes native species which does or is likely to cause economic or environmental harm.
nutrient loading	Discharging of nutrients from the watershed (basin) into a receiving water body (lake, stream, wetland).
output (sales)	Related to socioeconomics, output represents the value of industry production. In IMPLAN these are annual production estimates for the year of the data set and are in producer prices. For manufacturers this would be sales plus/minus change in inventory. For service sectors production = sales. For Retail and wholesale trade, output = gross margin and not gross sales.
PacifiCorp	An electric power company in the northwestern United States that owns and operates the Klamath River dams.
pathogenicity	The ability of an organism to cause disease.
pelagic	Relating to or occurring, living in, or frequenting the open ocean.
penstock	A pipe or conduit that carries water to a power generation turbine.
perennial	Flows continuously throughout the year.
periphyton	A complex mixture of algae, bacteria, their secretions, associated detritus, and various species of microinvertebrates attached to submerged surfaces in most aquatic ecosystems.
permeability	The ease with which water passes through sediment, depending on the composition and degree of packing of the sediment and viscosity of the water.
phytoplankton	Small, photosynthetic aquatic organisms, including diatoms, green algae, and cyanobacteria (blue-green algae).
place of use (POU)	The geographic area specified in a water right permit or license issued by the SWRCB, wherein the water may be used.
point source pollution	Pollution into bodies of water from specific discharge points such as sewer outfalls or industrial-waste pipes.
polychaete	Aquatic annelid worms belonging to the Class Polychaeta, segmented and have bristles for movement or attachment.
powerhouse	Structure that contains the power generation equipment such as the turbine, may be an enclosed building or an open area with concrete slabs and equipment.
preferred alternative	Alternative that the agency has determined is their preferred course of action.
preserve	To protect, keep, or maintain the condition of.
Project Team	The group of lead, cooperating, and responsible agencies responsible for evaluating the alternatives in the Environmental Impact Statement/Report.
proposed action	To increase lower Klamath River flows to reduce the likelihood, and potentially reduce the severity, of any fish die-off in future years due to crowded holding conditions for pre-spawn adults, warm water temperatures, and presence of disease pathogens which are likely the major factors contributing to the adult mortalities.
proposed species	A species of animal or plant that is proposed in the Federal Register to be listed under Section 4 of the Federal ESA.
public involvement	Process of obtaining citizen input into each stage of the development of planning documents. Required as a major input into any EIS.
public trust	The legal doctrine that protects the rights of the public to use water courses for commerce, navigation, fisheries, recreation, open space, preservation of ecological units in their natural state, and similar uses for which those lands are uniquely suited. It is based on the California State Constitution and goes back to English Common Law. The California Supreme Court states, “The state has an affirmative duty to take the public trust into account in the planning and allocation of water resources, and to protect public trust uses whenever feasible.” National Audubon (33Cal.3d 419 1983).
Reclamation	U.S. Department of the Interior, Bureau of Reclamation

Term	Definition
Reclamation's Klamath Project	The system of reservoirs, dams, canals, and pumps built to drain and reclaim lake bed lands of the Lower Klamath and Tule Lakes, to store water of the Klamath and Lost Rivers, to divert irrigation supplies, and to control flooding of the reclaimed lands.
reclassify	To change a species' official status from threatened to endangered or vice-versa.
Record of Decision (ROD)	Concise, public, legal document required under the NEPA that identifies and publicly and officially discloses the responsible official's decision on an alternative selected for implementation. It is prepared following completion of an EIS.
recovery	The process by which the decline of an endangered or threatened species is stopped or reversed, or threats to its survival neutralized so that its long-term survival in the wild can be ensured, and it can be removed from the list of threatened and endangered species.
Recovery Plan	A document drafted by the USFWS, NMFS, or other knowledgeable individual or group, that serves as a guide for activities to be undertaken by Federal, State, or private entities in helping to recover and conserve endangered or threatened species.
redd	A nest prepared by a female fish in streambed gravel, where she deposits her eggs.
refuge	Wildlife refuges -- certain portions of land set aside and managed by the USFWS or California Department of Fish and Wildlife (CDFW) to provide a water supply and vegetative habitat for migrating waterfowl and wildlife.
relicensing	The administrative proceeding in which Federal Energy Regulatory Commission (FERC), in consultation with other federal and state agencies, decides whether and on what terms to issue a new license for an existing hydroelectric project at the expiration of the original license.
reservoir	Artificially impounded body of water.
reservoir storage capacity	Reservoir capacity normally usable for storage and regulation of reservoir inflows to meet established reservoir operating requirements.
resident fish	Fish that remain in freshwater and do not migrate to the ocean.
Resource Agencies	Government entities that have jurisdictional authority over various natural resources.
restoration	Measures that develop or improve the quality or quantity of existing conditions or resources.
reverse flow	The flows in the western Delta are tidally influenced, with channel flows both towards and away from the ocean during a tidal cycle and the net flow usually towards the ocean. Reverse flows are assumed to occur when the net flow in the western Delta is away from the ocean.
riffle	A shallow reach with swiftly flowing, turbulent water and some partially exposed river bed material.
riparian	Vegetation or other resources associated with a river that are dependent on groundwater and floodwater controlled by the river. The land adjacent to a natural watercourse such as a river or stream. Riparian areas often support vegetation that provides important wildlife habitat, and important fish habitat values when growing large enough to overhang the bank.
riparian corridor	Land adjacent to creeks, rivers, and streams where vegetation is strongly influenced by the presence of water.
riparian vegetation	Of, adjacent to, or living on, the bank of a river or, sometimes, of a lake, pond, etc.
river mile	Measure of distance in miles along a river from its mouth. River mile numbers begin at zero and increase further upstream.
river mouth	The place where a river ends by flowing into another body of water such as a lake, ocean, or another river.
riverine	Of or pertaining to rivers.
run (of salmonids)	A group of fish that is migrating from the ocean to spawn in the rivers or streams where they were born.
Sacramento-San Joaquin River Delta (Delta)	As described in Section 12220 of the California Water Code, an area that generally extends from Sacramento to the north, Tracy to the south, Interstate 5 to the east, and Collinsville to the west. The Delta covers approximately 738,000 acres.

Term	Definition
salinity	The amount of dissolved salts in a given volume of water.
salmonids	Of, belonging to, or characteristic of the family Salmonidae, which includes salmon, trout, and whitefish.
salts	Compounds derived from the reaction of an acid and a base.
scoping	The open process that continues throughout the planning and early stages of preparation of an EIS for determining the scope of issues to be addressed and for identifying the significant issues related to a proposed action. For an EIS, Federal agencies must use scoping to engage state, local, and tribal governments and the public in the early identification of concerns, potential impacts, additional disciplines to be included, relevant effects of past actions, and possible alternative actions.
sediment	Rock and mineral particles transported by water. Sediment relevant to wetlands tends to be relatively fine because the low gradients involved do not transport larger particles.
sedimentation	The deposition by settling of a suspended material.
sentinel fish	Fish species that accumulate contaminates in their tissues and are used as indicators of pollution.
settlement	A downward movement of a surface as a result of underlying soil compression or consolidation caused by an increased load or the loss of underlying soil (foundation) support.
smolt	A young salmon that has assumed the silvery color of the adult and is ready to migrate to the sea.
soil moisture content	The weight of water contained in a sample of soil, typically expressed as a percentage of the dry weight of the soil.
spawner	Parental stock of a fish. Typically refers to an adult anadromous fish, like a salmon, on its upstream migration to spawn.
spawning	The releasing and fertilizing of eggs by fish.
special-status species	Federal and State classifications for plant and animal species that either are listed as threatened or endangered, are formally recognized candidates for listing, or are declining to a point where they may be listed.
spill	Water released from reservoirs to comply with flood control criteria.
spillway	Overflow structure of a dam.
stage	Water surface elevation; the elevation above mean sea level (msl), typically measured in feet.
stakeholder	Anyone who lives in a watershed or has land management, administrative, or other responsibilities or interests in it. Stakeholders may be individuals, businesses, government agencies, or special-interest groups.
State Water Project (SWP)	A California State water storage and conveyance system that pumps water from the Delta for agricultural, urban, domestic, and industrial purposes. The SWP was authorized by legislation in 1951 and consists of 22 dams and reservoirs, which delivers water 600 miles from the Sacramento Valley to Los Angeles.
stratification (in lakes)	The formation of layers based on temperature, oxygen levels, salinity, and density that act as barriers to water mixing.
stressors	Physical, chemical, or biological perturbations to a system that adversely affect ecosystem processes, habitats, and species. Examples include water diversions, dams, reservoirs, weirs, levees, bridges and bank protection, dredging and sediment disposal, gravel mining, invasive aquatic plants, invasive aquatic organisms, invasive riparian and salt marsh plants, nonnative wildlife, predation and competition, contaminants, wildfire, fish and wildlife harvest, and artificial fish propagation.
subsidence	A local mass movement that involves principally the gradual downward settling or sinking of the earth's surface with little or no horizontal motion. It may be due to natural geologic processes or mass activity such as removal of subsurface solids, liquids, or gases, groundwater extraction, and wetting of some types of moisture-deficient loose or porous deposits.
subsistence	The way by which a culture obtains its food.
subspecies	A taxonomic rank below that of species, usually recognizing individuals that have certain heritable characteristics distinct from other subspecies of a species.

Term	Definition
succession	The change in the composition and structure of a biological community over time in the absence of major disturbance (e.g., fire, flood, land clearing) in which the community modifies the physical environment to eventually establish an ecosystem that is as stable as possible at the site in question.
surface water diversion	Water that is diverted and/or pumped from aboveground sources such as rivers, streams, reservoirs, and lakes, as opposed to groundwater, which is pumped from an aquifer.
sustainable yield	Sustainable yield is a balance between pumping and basin recharge, and is expressed as the number of acre-feet of water per year that can be pumped from a basin on a long-term average annual basis.
tailwater	Water immediately downstream from a dam.
take	Under the Federal ESA, "To harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct" in regard to Federally listed, endangered species of wildlife (16 USCA 1532[19]). "Harm" is further defined as an act "which actually kills or injures." Harm may include "significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or shelter" (50 CFR 17.3). Under the California Fish and Game Code, take is defined as "to hunt, pursue, catch, capture, or kill, or attempt to hunt, pursue, catch, capture, or kill" (California Fish and Game Code Section 86).
terrestrial species	Types of species of animals and plants that live on or grow from the land.
thalweg	The deepest part of a stream or river channel.
thermal refugia	Cool, well-oxygenated areas of rivers utilized by salmon and other species to avoid thermal stress.
theronts	The infective stage of a parasitic protozoa such as Ich. During this stage, the pathogen becomes water-borne and can be transmitted.
threatened species	Legal status afforded to plant or animal species that are likely to become endangered within the foreseeable future throughout all or a significant portion of their range, as determined by the USFWS or the NMFS.
tomites	Infective stages of a parasitic protozoa, such as Ich, produced by cysts (tomonts). Tomites are then released as theronts.
tomonts	The cyst stage of a parasitic protozoa such as Ich. During this stage, cysts are released into the aquatic environment.
Total Maximum Daily Load (TMDL)	A regulatory term in the Clean Water Act that describes the maximum amount of a pollutant that a body of water can receive while still meeting water quality standards.
toxigenic	Producing or containing toxins.
toxins	Substances that cause damage to a living tissue, impairment of the central nervous system, severe illness, or death when ingested, inhaled, or absorbed by the skin.
tributary	A stream flowing into a larger stream or a lake.
Trinity River Division (TRD)	The Trinity River Division, part of Reclamation's Central Valley Project, consists of Trinity Dam and Trinity Lake, Trinity Powerplant, Lewiston Dam and Lake, Lewiston Powerplant, Clear Creek Tunnel, Judge Francis Carr Powerhouse, Whiskeytown Dam and Lake, Spring Creek Tunnel and Powerplant, Spring Creek Debris Dam and Reservoir, and related pumping and distribution facilities. The TRD transfers water from the Trinity River subbasin (part of the Klamath River Basin) to the Sacramento River Basin.
Trinity River Restoration Program (TRRP)	Restoration program to restore the Trinity River and its habitat for fish by augmenting flows, constructing rehabilitation sites, augmenting spawning gravel, and controlling fine sediments.
turbidity	A measure of the extent to which light passing through water is reduced owing to suspended materials.
Upper Klamath Basin	The portion of the Klamath River Basin located upstream of Iron Gate Dam.
water acquisition	The procurement (purchase) of water by Reclamation from willing sellers for delivery to and use by wildlife refuges.

Term	Definition
water rights	California recognizes riparian and appropriative water rights.
	Riparian Water Rights – Exist for lands that abut a waterway, or that overlie an underground stream. Generally, there is no riparian right to diffused surface waters or swamps. The extent of the frontage along a waterway in no way governs the quantity of the water right. Use of water through riparian rights must be on riparian land and within the watershed of a stream. Riparian rights may not be lost as a result of nonuse.
	Appropriative Water Rights – Water rights based on the principle of prior appropriations, or "first in time, first in right." To maintain appropriative water rights, the right to any water must be put to beneficial use. Nonuse of appropriative water rights may result in the loss of those water rights. In a conflict between a riparian water user and an upstream appropriator, the riparian user has priority, provided that the water is being used in a reasonable and beneficial manner.
water supply reliability	The certainty or degree to which water supplies are available for agricultural, municipal and industrial, and environmental purposes. For example, the degree to which water service contract holders receive their full-service contract amounts within acceptable quality, timing, and other service standards.
water transfer	Sales of water from the rights holder to another user by mutual agreement.
water year	The period of time beginning October 1 of one year and ending September 30 of the following year and designated by the calendar year in which it ends. Water Year 2008, for example, began October 1, 2007, and ended September 30, 2008. Water years are typically used in analyses of water supply rather than calendar years.
water year type	**Sacramento** – Classified based on the "Sacramento River Index" which defines the water year types based on flow in million acre-feet as follows: Wet - Equal to or greater than 9.2 Above Normal - Greater than 7.8, and less than 9.2 Below Normal - Greater than 6.5, and equal to or less than 7.8 Dry - Greater than 5.4, and equal to or less than 6.5 Critical - Equal to or less than 5.4.
	Trinity – Classified based on historical river flows in the Trinity River Basin. The Final Trinity Mainstem Fishery Restoration Environmental Impact Statement/Report defines the water year types based on flow in thousand acre-feet as follows: Extremely Wet - Equal to or greater than 2,000 Wet - Greater than 1,350, and less than 2,000 Normal - Greater than 1,025, and less than 1,350 Dry - Greater than 650, and less than 1,025 Critically Dry - Equal or less than 650.
watershed	The total land area that drains to any point in a stream. An area that drains to a particular channel or river, usually bounded peripherally by a natural divide of some kind such as a hill, ridge, or mountain.
wetland	Areas that are inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas.
Wildlife Management Area (WMA)	A refuge managed by the CDFW.
willing sellers	A term used to describe entities (water districts, agencies, individuals, etc.) who would be interested in selling their water supplies under transfer guidelines established by the SWRCB and other regulatory agencies.

Term	Definition
X2	The location (measured in kilometers from the Golden Gate Bridge) of 2 parts per thousand total dissolved solids. The length of time X2 must be positioned at set locations in the estuary each month is determined by a formula that considers the previous month's inflow to the Delta and a "Level of Development" factor, denoted by a particular year. X2 is currently used as the primary indicator in managing Delta outflows. The X2 indicator is also used to reflect a variety of biological consequences related to the magnitude of fresh water flowing downstream through the estuary and the upstream flow of salt water in the lower portion of the estuary. The outflow that determines the location of X2 also affects both the downstream transport of some organisms and the upstream movement of others and affects the overall water operations of the CVP and SWP.

RECLAMATION

Managing Water in the West

Environmental Impact Statement Analytical Tools Technical Appendix

Long-Term Plan to Protect Adult Salmon in the Lower Klamath River
Draft

October 2016

Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

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Attachments

Attachment 1 – Selection of Analytical Tools

Abbreviations and Acronyms

°C	degrees Celsius
°F	degree Fahrenheit
1-D	1-dimensional
7DADM	7-day average daily maximum
ANN	artificial neural network
AR4	Fourth Assessment Report
BA	Biological Assessment
BO	Biological Opinion
CES	Constant Elasticity of Substitution
cfs	cubic feet per second
cm	centimeter
CMIP3	Coupled Model Intercomparison Project Phase 3
CMIP5	Coupled Model Intercomparison Project Phase 5
CVP	Central Valley Project
CVPM	Central Valley Production Model
Delta	Sacramento-San Joaquin River Delta
DFG	California Department of Fish and Game
DSM2	Delta Simulation Model 2
DWR	California Department of Water Resources
EC	electrical conductivity
EIS	Environmental Impact Statement
GCM	global climate models
GHG	greenhouse gas emission
IMPLAN	IMpact Analysis for PLANning Model
I-O	input-output
IOS	Interactive Object-Oriented Salmonid Simulation
IPCC	Intergovernmental Panel on Climate Change
LTO BA	*Biological Assessment on the Continued Long-term Operations of the Central Valley Project and the State Water Project*
LTO	*Coordinated Long-Term Operation of the Central Valley Project and State Water Project*
LYRA	Lower Yuba River Accord
NAICS	North American Industry Classification System
NEPA	National Environmental Policy Act
OCO	Operations Control Office
PMP	Positive Mathematical Programming
RBM10	River Basin Model 10
Reclamation	U.S. Department of the Interior, Bureau of Reclamation
ROD	Record of Decision

RPA	Reasonable and Prudent Alternatives
SALMOD	Salmonid Population Model
SWAP	Statewide Agricultural Production Model
SWP	State Water Project
SWRCB	State Water Resources Control Board
TAF	thousand acre-feet
TRD	Trinity River Division
UCCE	University of California Cooperative Extension
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Service
VIC	Variable Infiltration Capacity
Western	Western Area Power Authority
WRESL	water resources simulation language
YTFP	Yurok Tribal Fisheries Program

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Chapter 1
Overview of Analytical Framework and Modeling

This chapter summarizes the overall analytical framework and modeling methodology used to assess the No Action and action alternatives in this Environmental Impact Statement (EIS). Chapters 2 through 7 describe the tools and procedures used in the analyses for this EIS, including the application of these tools, the types of outputs generated, and the appropriate use of these outputs, by resource area. Attachment 1, "Selection of Analytical Tools," describes the rationale for selection of the analytical tools used to assess resource area impacts.

Overview of the Modeling Approach

To support the impact analysis of the alternatives, numerical modeling of physical variables (or "physically based modeling"), such as river flows and water temperature, is required to evaluate changes to conditions affecting resources in the Klamath, Trinity, and Sacramento systems, including the Sacramento-San Joaquin River Delta (Delta). A framework of integrated analyses including hydrologic operations, hydrodynamics, water quality, and fisheries analyses is required to provide information for the comparative National Environmental Policy Act (NEPA) assessment of several resources, such as water supply, surface water, and aquatic resources.

As discussed in Chapter 2, "Description of Alternatives, the alternatives include operational changes of the Trinity River Division (TRD) of the Central Valley Project (CVP) in order to provide flow augmentation to the lower Klamath River in August and September in drier years. These operational changes and other external factors, such as climate and sea-level changes, influence the future conditions of reservoir storage, river flow, Delta flows, exports, water temperature, and water quality. Evaluation of these conditions is the primary focus of the physically based modeling analyses. Results of these physical models are used as input to fisheries models. In addition, economic models are used to evaluate impacts to agricultural production and regional economics.

Figure 1-1 shows the analytical tools applied in these assessments and the relationship between these tools. Each model included in Figure 1-1 provides information to the subsequent model in order to provide various results to support the impact analyses.

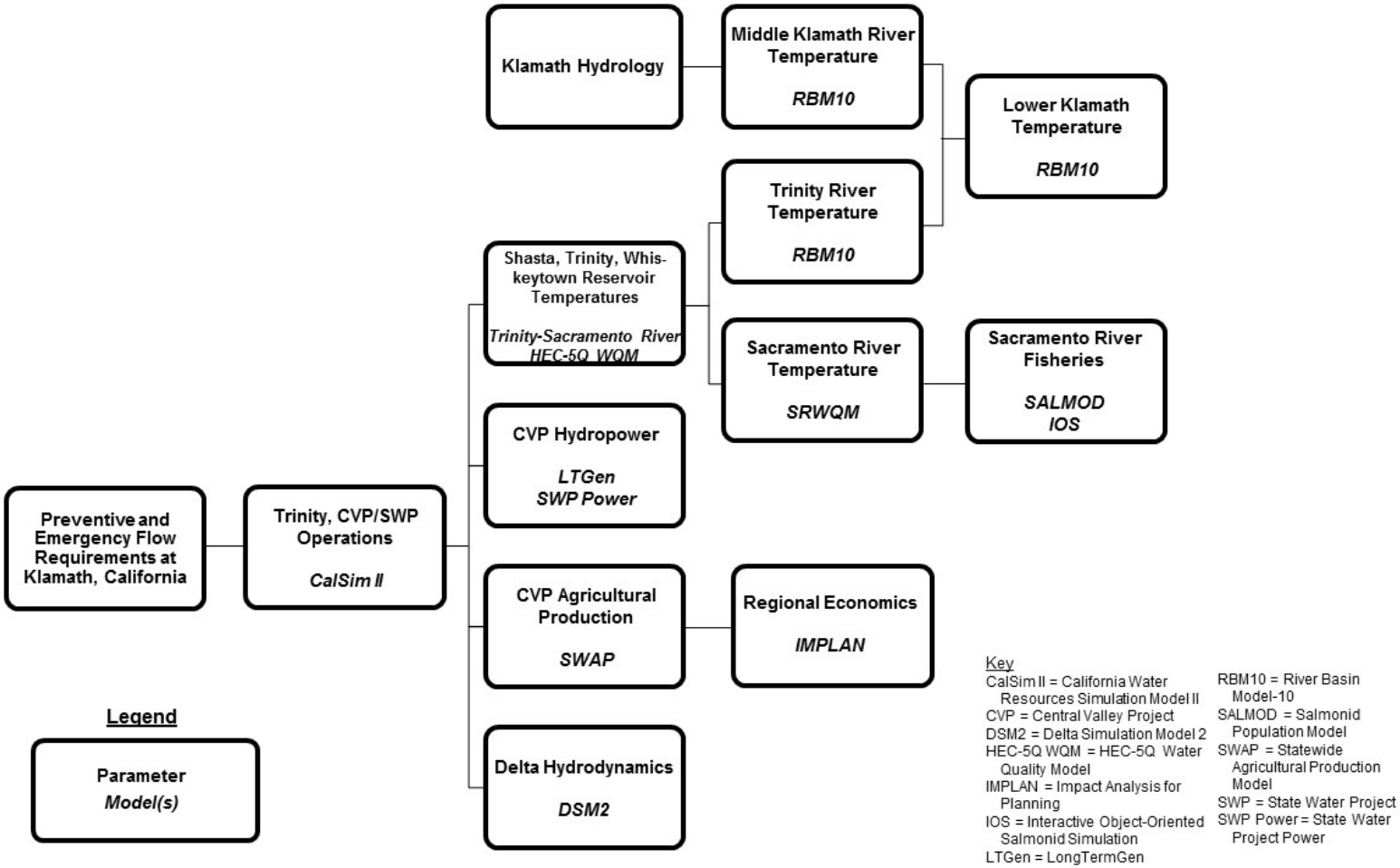

Figure 1-1. Analytical Framework Used to Evaluate Impacts of the Alternatives

Changes to the historical hydrology related to the future climate are applied in the CalSim II model and combined with the assumed operations for each alternative. The CalSim II model simulates the operation of the major CVP and State Water Project (SWP) facilities in the Central Valley and generates estimates of river flows, exports, reservoir storage, deliveries, and other parameters.

Temperature models for the primary river systems and streams (i.e., Trinity River, lower Klamath River, Sacramento River, Clear Creek) use the CalSim II reservoir storage, reservoir releases, river flows, and meteorological conditions to estimate reservoir and river temperatures under each alternative. Results from these temperature models are further used as an input to fisheries models (e.g., SALMOD, IOS) to assess changes in fisheries habitat due to flow and temperature.

Power generation models use CalSim II reservoir levels and releases to estimate power use and generation capability of the projects. Changes in energy generation and use reported by the hydropower models are subsequently used to assess changes in greenhouse gas emissions (GHG).

Agricultural deliveries resulting from CalSim II are used for assessment of changes in agricultural production and regional economics. Changes in land use reported by the agricultural economics model are subsequently used to assess changes in air quality.

Delta Simulation Model 2 (DSM2) Delta hydrodynamic and water quality models use CalSim II boundary inflow conditions for estimating tidally based flows, stage, velocity, and salt transport within the estuary.

The results from this suite of physically based models are used to describe the effects of each alternative considered in this EIS.

Climate Change and Sea-Level Rise Considerations

A growing body of evidence indicates that Earth's atmosphere is warming. Records show that surface temperatures have risen about 0.7 degrees Celsius (°C) since the early twentieth century and that 0.5°C of this increase has occurred since 1978 (NAS 2006). Observed changes in oceans, snow and ice cover, and ecosystems are consistent with this warming trend (NAS 2006, IPCC 2007). In addition, global and regional sea levels have been increasing steadily over the past century and are expected to continue to increase throughout this century. Over the past several decades, sea level measured at tide gages along the California coast has risen at a rate of about 17 to 20 centimeters (cm) (6.7 to 7.9 inches) per century (Cayan et al. 2009).

This EIS uses a representation of potential climate change and sea-level rise change in numerical models that simulate hydrologic and hydrodynamic conditions in the study area in addition to changes in river flows due to changes in operations and diversions. For modeling purposes, the alternatives are simulated at anticipated 2030 conditions. In the evaluation of all alternatives at 2030, climate change and a sea-level rise of 15 cm were assumed to be inherent. For details on

the incorporation of climate change and sea-level rise considerations in individual models, see the individual model chapters.

Model Results Presentation

Figures and tables are provided to illustrate and summarize the results in Chapters 4 through 14 of this EIS. The different types of presentations are explained below.

Exceedance Plots. Exceedance plots provide the percent of time that a given value is exceeded over the course of the analysis. Exceedance plots are generated by ranking or sorting the data and computing the percent of time that value is exceeded in the data. For example, for the Shasta storage end of September exceedance plot, Shasta storage values at the end of September for each simulated year are sorted in ascending order. The smallest value would have an exceedance of 100 percent since all other values would be greater than that value, and the largest value would have an exceedance of 0 percent. All the values are plotted with exceedance on the x-axis and the value of the parameter on the y-axis. Following the same example, if for one scenario, Shasta end of September of 2,000 thousand acre-feet (TAF) corresponds to 80 percent exceedance, it implies that Shasta end-of September storage is higher than 2,000 TAF in 80 percent of the years under the simulated conditions.

Long-Term Average Summary and Year Type Based Statistics Summary Tables. These tables provide parameter values for long-term and year type averages (using the Sacramento Valley 40-30-30 Index developed by the State Water Resources Control Board (SWRCB) or the Trinity Restoration water year types depending on location) for each month. Tables of water supply deliveries do not show the month by month comparison but rather delivery year (March-February) totals by water year type.

Appropriate Use of Model Results

Types of Evaluations

Resource area evaluations for the alternatives were based on quantitative and qualitative assessments using output from model simulations, other analytical tools, previous studies, or other existing information. Each resource area was evaluated by applying one or more of the following methods.

Comparison of Quantitative Simulations – Some models provide quantitative output used for direct comparisons between the No Action Alternative and the action alternatives to identify effects on resources from implementation. For example, output from system water supply operations simulations were directly compared to identify changes in reservoir levels, river flow, and water supply deliveries to the CVP and SWP.

Interpretation/Extrapolation from Quantitative Simulations – Many of the quantitative models providing output for direct comparisons of effects on resources, as described above, were used to interpret/extrapolate effects on other resources. For example, output from system water supply operation simulations informed the evaluation of effects to terrestrial resources due to

changes in river flows. Similarly, other models were used solely to provide quantitative data for interpretation or extrapolation on the effects to various resources.

Interpretation/Extrapolation from Available Data or Previous Studies – Existing data and information from previous studies were used to interpret/extrapolate the effects on resources when model simulations were not available, needed or feasible. For example, implementation effects on cultural resources were identified in part through a review of previously conducted archaeological and historical studies.

Qualitative Description with Limited or No Data – When available data or previous studies were limited or unavailable, a qualitative description of the effects were developed using professional judgment and any limited data that were available.

Appropriate Use of Model Results

Interpretation of results from any of the above evaluation methods should consider the physical models developed and applied in the EIS analysis are generalized and simplified representations of a complex water resources system. A brief description of appropriate use of the model results to compare two scenarios or to compare against threshold values or standards is presented below.

Absolute vs. Relative Use of the Model Results. The models are not predictive models (in how they are applied in this project), and therefore the results cannot be considered as absolute with and within a quantifiable confidence interval. The model results are only useful in a comparative analysis and can only serve as an indicator of condition (e.g., compliance with a standard) and of trends (e.g., generalized impacts).

Statistical Comparisons. Using absolute differences computed at a point in time between model results from an alternative and a baseline to evaluate impacts is an inappropriate use of model results (e.g., computing differences between the results from a baseline and an alternative for a particular day or month and year within the period of record of simulation). Likewise computing absolute differences between an alternative (or a baseline) and a specific threshold value or standard is an inappropriate use of model results. Statistics computed based on the absolute differences at a point in time (e.g., average of monthly differences) are an inappropriate use of model results. Computing the absolute differences in this way disregards the changes in antecedent conditions between individual scenarios and distorts the evaluation of impacts of a specific action.

Appropriate statistics to use in summarizing model results are long-term averages and averages by month and water-year type, but the emphasis in using these results should be on evaluating the differences in these averages between alternatives, rather than the absolute values of averages for a particular alternative. Care should be taken to use the appropriate water year type for presenting water year type average statistics of model results (e.g., water year indices should reflect any climate change modifications at the analysis horizon). For this study, water year types are based on the projected climate and hydrology at year 2030.

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Chapter 2
Water Operations Modeling

As discussed in Attachment 1, " Selection of Analytical Tools" to this Appendix, CalSim II was chosen as the model to simulate and evaluate water operations in the upper Trinity River Basin, Sacramento River Basin, San Joaquin River Basin, the Delta, and CVP facilities and Service Areas, including the TRD facilities.

The CalSim II simulation model uses single time-step optimization techniques to route water through a network of storage nodes and flow arcs based on a series of user-specified relative priorities for water allocation and storage. Physical capacities and specific regulatory and contractual requirements are input as linear constraints to the system operation using the water resources simulation language (WRESL). The process of conveying water through the channels and storing water in reservoirs is performed by a mixed-integer linear-programming solver. For each time step, the solver maximizes the objective function to determine a solution that delivers or stores water according to the specified priorities and satisfies all system constraints. The sequence of solved linear-programming problems represents the simulation of the system over the period of analysis.

CalSim II includes an 82-year modified historical hydrology (water years 1922-2003) developed jointly by the U.S. Department of the Interior, Bureau of Reclamation (Reclamation) and the California Department of Water Resources (DWR). Water diversion requirements (demands), stream accretions and depletions, rim basin inflows, irrigation efficiencies, return flows, nonrecoverable losses, and groundwater operations are components that make up the hydrology used in CalSim II. Sacramento Valley and tributary rim basin hydrologies are developed using a process designed to adjust the historical observed sequence of monthly stream flows to represent a sequence of flows at a future level of development. Adjustments to historic water supplies are determined by imposing future level land use on historical meteorological and hydrologic conditions. The resulting hydrology represents the water supply available from Central Valley streams to the system at a future level of development.

CalSim II uses rule-based algorithms for determining deliveries to north-of-Delta and south-of-Delta CVP and SWP contractors. This delivery logic uses runoff forecast information, which incorporates uncertainty and standardized rule curves. The rule curves relate storage levels and forecasted water supplies to project delivery capability for the upcoming year. The delivery capability is then translated into CVP and SWP contractor allocations that are satisfied through coordinated reservoir-export operations.

The CalSim II model utilizes a monthly time step to route flows throughout the river-reservoir system of the Central Valley. Although monthly time steps are reasonable for long-term planning analyses of water operations, a component of the EIS conveyance and conservation strategy includes operations that are sensitive to flow variability at scales less than monthly (i.e., the operation of the Fremont Weir). Initial comparisons of monthly versus daily operations at these facilities indicated that weir spills were likely underestimated and diversion potential was likely

overstated using a monthly time step. For these reasons, a monthly to daily flow disaggregation technique was included in the CalSim II model for the Fremont Weir and the Sacramento Weir. The technique applies historical daily patterns, based on the hydrology of the year, to transform the monthly volumes into daily flows. Reclamation's 2008 *Biological Assessment on the Continued Long-term Operations of the Central Valley Project and the State Water Project* (LTO BA) Appendix D provides more information about CalSim II (Reclamation 2008a).

Application of CalSim II to Evaluate EIS Alternatives

Typical long-term planning analyses of the operations of the CVP and SWP have applied the CalSim II model to analyze system responses. CalSim II simulates future CVP and SWP project operations based on an 82-year monthly hydrology derived from the observed 1922-2003 period. Future land use and demands are projected for the appropriate future period. The system configuration of facilities, operations, and regulations forms the input to the model and defines the limits or preferences for operation. The configuration of the Delta, while not simulated directly in CalSim II, informs the flow-salinity relationships and several flow-related regressions for interior Delta conditions included in the model. The CalSim II model is simulated for each set of hydrologic, facility, operations, regulations, and Delta configuration conditions. Some refinement of the CVP and SWP operations related to delivery allocations and San Luis target storage levels are generally necessary to have the model reflect suitable Trinity-Sacramento basin and north-south CVP and SWP reservoir system balancing.

The CalSim II model produces outputs of river flows, exports, water deliveries, reservoir storage, water quality, and several derived variables such as X2 (distance in kilometers eastward from the Golden Gate Bridge to the location where salinity concentration is 2 parts per thousand), Delta salinity, OMR (combined Old and Middle River flows), and QWEST (westerly flow on the San Joaquin River past Jersey Point). The CalSim II model is most appropriately applied for comparing one alternative to another and drawing comparisons among the results – this is the method applied for the EIS. Each alternative is compared to the No Action Alternative to evaluate areas in which the project changes conditions and the seasonality and magnitude of such changes. The change in hydrologic response or system conditions is important information that informs the impact analysis related to water-dependent resources in Sacramento-San Joaquin watersheds.

Incorporation of Climate Change and Sea-Level Rise

Climate and sea level change were incorporated into the CalSim II model in two ways: changes to the input hydrology and changes to the flow-salinity relationship in the Delta due to sea-level rise.

Climate Change

In recent years, a suite of global climate models (GCM) has been developed and refined as part of the Coupled Model Intercomparison Project Phase 3 (CMIP3), part of the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (AR4). To incorporate climate change into CalSim II modeling, climate change scenarios developed from an ensemble of 112 bias-corrected, spatially downscaled GCM simulations were considered. The future projected changes over the 30-year climatological period centered on 2025 (i.e., 2011-2040 to represent

2025 timeline) were combined with a set of historically observed temperatures and precipitation to generate climate sequences that maintain important multi-year variability not always reproduced in direct climate projections.

In an effort to summarize these 112 scenarios, five statistically representative climate change scenarios were developed to characterize the central tendency, and the range of the ensemble uncertainty. Since the ensemble is made up of many projections, it is useful to identify the median (50th percentile) change of both annual temperature and annual precipitation. In doing so, the state of climate change at this point in time can be broken into quadrants representing (1) drier, less warming, (2) drier, more warming, (3) wetter, more warming, and (4) wetter, less warming than the ensemble median (Q1 through Q4). In addition, a fifth region (Q5) can be described that samples from inner-quartiles (25th to 75th percentile) of the ensemble and represents a central region of climate change. In each of the five regions the sub-ensemble of climate change projections, made up of those contained within the region bounds, is identified. The Q5 scenario is derived from the central tending climate projections and thus favors the consensus of the ensemble.

For the purposes of this EIS, the Q5 climate change scenario for the period centered on 2025 is used for all alternatives analyses and represents conditions at 2030. Although projected changes in future climate contain significant uncertainty through time, several studies have shown that use of the median climate change condition is acceptable (for example, Pierce et al. 2009). The median climate change is considered appropriate for the EIS because of the comparative nature of the NEPA analysis. This EIS utilized the same climate change scenarios to develop CalSim II inputs as the *Coordinated Long-Term Operation of the Central Valley Project and State Water Project* (LTO) EIS (Reclamation 2015a). Additional information on the differences between Q5 and Q1-Q4 are presented in *Appendix 5A.A: CalSim II and DSM2 Modeling Methodology* of the LTO EIS.

After determining the climate change scenario to use for analysis, changes in runoff and stream flow are simulated through Variable Infiltration Capacity (VIC) modeling under this scenario. These simulated changes in runoff are applied to the CalSim II inflows as a fractional change from the observed inflow patterns (simulated future runoff divided by historical runoff). The changes in runoff are applied to runoff forecasts used for reservoir operations and allocation decisions; changes in stream flow are applied to all major streams in the Central Valley and Trinity River Basin. After determining the adjusted runoff and stream flows, water year types and other hydrologic indices that govern water operations or compliance were adjusted to be consistent with the new hydrologic regime. The changes in reservoir inflows, key valley floor accretions, and water year types and hydrologic indices were translated into modified input time series for the CalSim II model. Figure 2-1 shows inflows to Trinity Reservoir in CalSim II with and without the effects of climate change.

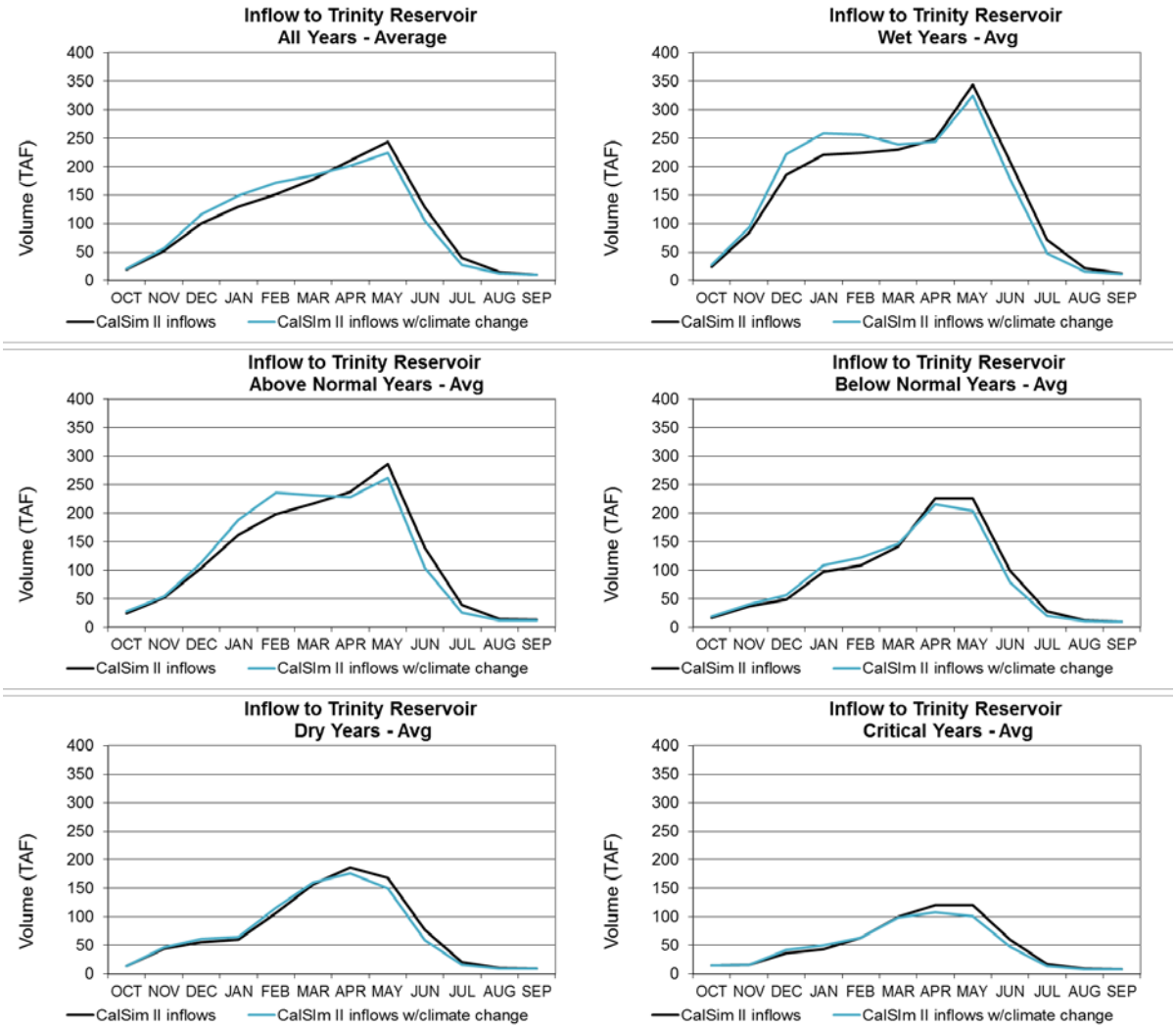


Figure 2-1. Comparison of Trinity Inflows in CalSim II With and Without the Effects of Climate Change

The CalSim II simulations do not consider future climate change adaptations that may manage the CVP and SWP system in a different manner than today to reduce climate impacts. For example, future changes in reservoir flood control reservation to better accommodate a seasonally changing hydrograph may be considered under future programs, but are not considered under the EIS. Thus, the CalSim II EIS results represent the risks to operations, water users, and the environment in the absence of dynamic adaptation for climate change.

Sea-Level Rise

Salinity in the Delta cannot be simulated accurately by the simple mass-balance routing and coarse time step used in CalSim II. Likewise, the upstream reservoirs and operational constraints cannot be modeled in the DSM2 model (Delta Simulation Model 2) (see Chapter 6 for discussion of DSM2 modeling). An artificial neural network (ANN) has been developed (Sandhu et al. 1999) that attempts to mimic the flow-salinity relationships as simulated in DSM2 while providing a rapid transformation of this information into a form usable by the CalSim II

operations model. The ANN is implemented in CalSim II to constrain the operations of the upstream reservoirs and the Delta export pumps in order to satisfy particular salinity requirements. ANN requires retraining whenever the flow-salinity relationship in the Delta changes.

For the purposes of the EIS, the sea-level rise scenario for the period centered on 2025 is used (DWR et al. 2013). This period is considered because the EIS analysis is conducted using the assumed conditions at 2030. For sea-level rise simulation, it was assumed the projected sea-level rise at 2025 would be approximately 12 to 18 cm (5 to 7 inches) (Rahmstorf 2007, Vermeer and Rahmstorf 2009). Due to the considerable uncertainty in these projections and the state of sea-level rise science, the mid-range of the estimates of 15 cm (6 inches) were used. . This sea-level rise estimate is consistent with those outlined in the recent U.S. Army Corps of Engineers (USACE) guidance circular for incorporating sea-level changes in civil works programs (USACE 2013). An ANN developed to simulate salinity conditions with 15-cm sea-level rise was obtained from Reclamation and used in the CalSim II modeling.

No Action Alternative Development

This section presents the assumptions used in developing the CalSim II model simulations of the No Action Alternative for use in the EIS evaluation. The assumptions were selected to satisfy NEPA requirements. Assumptions that were applied to the CalSim II modeling are included in the following section. The No Action Alternative assumptions represent the continuation of existing policy and management direction at Year 2030 and include implementation of water operations components of the Reasonable and Prudent Alternatives (RPA) actions specified in the *Formal Endangered Species Act Consultation on the Proposed Coordinated Operations of the Central Valley Project and State Water Project* (USFWS 2008) and the NMFS 2009 *Biological Opinion and Conference Opinion on the Long- Term Operations of the CVP and SWP* (NMFS 2009).

Modeling Assumptions

The No Action Alternative was developed assuming projected Year 2030 conditions. The No Action Alternative includes projected climate change and sea-level rise assumptions corresponding to the Year 2030. Climate change results in changes in the reservoir and tributary inflows included in CalSim II. The CalSim II simulation for the No Action Alternative does not consider any adaptation measures that would result in managing the CVP and SWP system in a different manner than it is managed today to reduce climate impacts. Table 2-1 summarizes assumptions made in CalSim II modeling for this analysis.

Inflows/Supplies

The CalSim II model includes historical hydrology projected to Year 2030 under climate change assumptions and with projected 2020 modifications for operations upstream of the rim reservoirs.

Land Development

CalSim II uses a hydrology that is the result of an analysis of agricultural and urban land use and population estimates. The assumptions used for Sacramento Valley land use result from

aggregation of historical survey and projected data developed for the California Water Plan Update (Bulletin 160-98). Generally, land-use projections are based on Year 2020 estimates; however, the San Joaquin Valley hydrology reflects draft 2030 land-use assumptions developed by Reclamation. Where appropriate, Year 2020 projections of demands associated with water rights and CVP and SWP water service contracts have been included.

Demands, Water Rights, and CVP and SWP Contracts

CalSim II demand inputs are preprocessed monthly time series for a specified level of development (e.g., 2020) and according to hydrologic conditions. Demands are classified as CVP project, SWP project, local project, or non-project. CVP and SWP demands are separated into different classes based on the contract type. A description of various demands and classifications included in CalSim II is provided in the 2008 LTO BA Appendix D (Reclamation 2008a).

Table 2-1. CalSim II Modeling Assumptions

	No Action Alternative[1]
Planning Horizon	2030
Period of Simulation	82 years (1922–2003)
HYDROLOGY	
Inflows/Supplies	Historical with modifications for operations upstream of rim reservoirs and with changed climate at Year 2030
Level of Development (land-use)	2020 and 2030 Level[2]
Demands	
Sacramento River Region (excluding the American River)	
CVP[3]	Land-use based, full build-out of contract amounts
SWP (FRSA)[4]	Land-use based, limited by contract amounts
Nonproject	Land-use based, limited by water rights and SWRCB Decisions for Existing Facilities
City of Antioch	Pre-1914 water right
Federal refuges[5]	Firm Level 2 water needs
Sacramento River Region – American River Basin[6]	
Water rights	Year 2025, full water rights
CVP	Year 2025, full contracts, including Freeport Regional Water Project (FRWP)
San Joaquin River Region[7]	
Friant Unit	Limited by contract amounts, based on current allocation policy
Lower basin	Land-use based, based on district level operations and constraints
Stanislaus River basin[8, 9]	Land-use based, based on New Melones Interim Operations Plan, up to full SEWD deliveries (155 TAF/year) depending on New Melones Index
San Francisco Bay, Central Coast, Tulare Lake, and South Coast Regions (CVP and SWP project facilities)	
CVP[3]	Demand based on contract amounts
Federal refuges[5]	Firm Level 2 water needs
CCWD[10]	CCWD Forecasted 2030 demands
SWP [4, 11]	Demand based on full Table A amounts (4.13 MAF/year)
Article 56	Based on 2001–2008 contractor requests
Article 21	MWD demand up to 200 TAF/month from December to March subject to conveyance capacity, KCWA demand up to 180 TAF/month and other contractor demands up to 34 TAF/month in all months, subject to conveyance capacity.
North Bay Aqueduct	77 TAF/year demand under SWP contracts, up to 43.7 cfs of excess flow under Fairfield, Vacaville, and Benicia Settlement Agreement. NOD Allocation Settlement Agreement terms for Napa and Solano
FACILITIES	
Systemwide	Existing facilities
Sacramento River Region	
Shasta Lake	Existing, 4,552 TAF capacity
Red Bluff Diversion Dam	Diversion dam operated with gates out all year, consistent with NMFS BO (June 2009) Action I.3.19.
Colusa Basin	Existing conveyance and storage facilities
Upper American River	PCWA American River pump station
Lower Sacramento River	FRWP

Table 2-1. CalSim II Modeling Assumptions (contd.)

	No Action Alternative[1]
Delta Region	
SWP Banks Pumping Plant (South Delta)	Physical capacity is 10,300 cfs but 6,680 cfs permitted capacity in all months up to 8,500 cfs during December 15–March 15, depending on Vernalis flow conditions[12]; additional capacity of 500 cfs (up to 7,180 cfs) allowed for reducing impact of NMFS BO (June 2009) Action IV.2.1[9] on SWP[13]
CVP C.W. "Bill" Jones Pumping Plant (formerly Tracy PP)	Permit capacity is 4,600 cfs in all months (allowed for by the Delta-Mendota Canal–California Aqueduct Intertie)
Upper DMC	Existing (exports limited to 4,200 cfs plus diversion upstream from DMC–constriction) plus 400 cfs Delta-Mendota Canal-California Aqueduct Intertie
Los Vaqueros Reservoir	Enlarged storage capacity, 160 TAF, existing pump location. Alternate Intake Project included[14]
San Joaquin River Region	
Millerton Lake (Friant Dam)	Existing, 520 TAF capacity
Lower San Joaquin River	City of Stockton Delta Water Supply Project, 30 mgd capacity
San Francisco Bay region	
South Bay Aqueduct	SBA rehabilitation, 430 cfs capacity from junction with California Aqueduct to Alameda County FC&WSD Zone 7 point
South Coast Region	
California Aqueduct East Branch	Existing Capacity
REGULATORY STANDARDS	
Trinity River	
Minimum Flow below Lewiston Dam	Trinity EIS Preferred Alternative (369-815 TAF/year)
Trinity Reservoir end-of-September minimum storage	Trinity EIS Preferred Alternative (600 TAF as able)
Clear Creek	
Minimum flow below Whiskeytown Dam	Downstream water rights, 1963 Reclamation proposal to USFWS and NPS, and USFWS predetermined CVPIA 3406(b)(2) flows15, and NMFS BO (June 2009) Action I.1.19
Upper Sacramento River	
Shasta Lake end-of-September minimum storage	NMFS 2004 Winter-run BO (1900 TAF in non-critical dry years), and NMFS BO (Jun 2009) Action I.2.19
Minimum flow below Keswick Dam	SWRCB WR 90-5, predetermined CVPIA 3406(b)(2) flows15, and NMFS BO (June 2009) Action I.2.29
Feather River	
Minimum flow below Thermalito Diversion Dam	2006 Settlement Agreement (700/800 cfs).
Minimum flow below Thermalito Afterbay outlet	1983 DWR and CDFW agreement (750 –1,700 cfs)
Yuba River	
Minimum flow below Daguerre Point Dam	D-1644 Operations (Lower Yuba River Accord)16

Table 2-1. CalSim II Modeling Assumptions (contd.)

	No Action Alternative[1]
American River	
Minimum flow below Nimbus Dam	American River Flow Management as required by NMFS BO (Jun 2009) Action II.1[9]
Minimum flow at H Street Bridge	SWRCB D-893
Lower Sacramento River	
Minimum flow near Rio Vista	SWRCB D-1641
Mokelumne River	
Minimum flow below Camanche Dam	FERC 2916-029, 1996 (Joint Settlement Agreement) (100–325 cfs)
Minimum flow below Woodbridge Diversion Dam	FERC 2916-029, 1996 (Joint Settlement Agreement) (25–300 cfs)
Stanislaus River	
Minimum flow below Goodwin Dam	1987 Reclamation, CDFW agreement, and flows required for NMFS BO (June 2009) Action III.1.2 and III.1.3[9, 17]
Minimum dissolved oxygen	SWRCB D-1422
Merced River	
Minimum flow below Crocker-Huffman Diversion Dam	Davis-Grunsky (180–220 cfs, November–March), and Cowell Agreement
Minimum flow at Shaffer Bridge	FERC 2179 (25–100 cfs)
Tuolumne River	
Minimum flow at Lagrange Bridge	FERC 2299-024, 1995 (Settlement Agreement) (94–301 TAF/year)
San Joaquin River	
San Joaquin River below Friant Dam/Mendota Pool	Full San Joaquin River Restoration flows
Maximum salinity near Vernalis	SWRCB D-1641
Minimum flow near Vernalis	SWRCB D-1641 (Feb-Apr 14 and May 16-June minimum flows only).[18] NMFS BO (June 2009) Action IV.2.1 Phase II flows not provided due to lack of agreement for purchasing water.
Sacramento-San Joaquin Delta	
Delta Outflow Index (flow and salinity)	SWRCB D-1641 and USFWS BO (December 2008) Action 49
Delta Cross Channel gate operation	SWRCB D-1641 with additional days closed from October 1–January 31 based on NMFS BO (June 2009) Action IV.1.29 (closed during flushing flows from October 1–December 14 unless adverse water quality conditions)
South Delta exports (Jones PP and Banks PP)	SWRCB D-1641 export limits, not including VAMP period export cap under the San Joaquin River Agreement; Vernalis flow-based export limits in April–May as required by NMFS BO (June 2009) Action IV.2.1 Phase II90 (additional 500 cfs allowed for July–September for reducing impact on SWP)13
Combined Flow in Old and Middle River (OMR)	USFWS BO (December 2008) Actions 1, 2, and 3 and NMFS BO (June 2009) Action IV.2.39

Table 2-1. CalSim II Modeling Assumptions (contd.)

	No Action Alternative[1]
OPERATIONS CRITERIA: RIVER-SPECIFIC	
Upper Sacramento River	
Flow objective for navigation (Wilkins Slough)	NMFS BO (June 2009) Action I.4[9]; 3,500 – 5,000 cfs based on CVP water supply condition
American River	
Folsom Dam flood control	Variable 400/670 flood control diagram (without outlet modifications)
Feather River	
Flow at mouth of Feather River (above Verona)	Maintain CDFW/DWR flow target of 2,800 cfs for April–September dependent on Oroville inflow and FRSA allocation
Stanislaus River	
Flow below Goodwin Dam	Revised Operations Plan and NMFS BO (June 2009) Action III.1.2 and III.1.3[9,17]
San Joaquin River	
Salinity at Vernalis	Grassland Bypass Project (full implementation)
OPERATIONS CRITERIA: SYSTEMWIDE	
CVP Water Allocation	
CVP settlement and exchange	100% (75% in Shasta critical years)
CVP refuges	100% (75% in Shasta critical years)
CVP agriculture	100%–0% based on supply. South-of-Delta allocations are additionally limited due to D-1641, USFWS BO (December 2008), and NMFS BO (June 2009)[9], and are always 0% when Shasta storage < 2400 TAF during Shasta critical years.
CVP municipal & industrial	100%–50% based on supply. South-of-Delta allocations are additionally limited due to D-1641, USFWS BO (December 2008), and NMFS BO (June 2009)[9]
SWP Water Allocation	
North of Delta (FRSA)	Contract specific
South of Delta (including North Bay Aqueduct)	Based on supply; equal prioritization between Ag and M&I based on Monterey Agreement; allocations are limited due to D-1641, USFWS BO (December 2008), and NMFS BO (June 2009)[9]
CVP/SWP Coordinated Operations	
Sharing of responsibility for in-basin use	1986 Coordinated Operations Agreement (FRWP, EBMUD, and 2/3 of the North Bay Aqueduct diversions are considered as Delta export, 1/3 of the North Bay Aqueduct diversion is considered as in-basin use)
Sharing of surplus flows	1986 Coordinated Operations Agreement
Sharing of restricted export capacity for project-specific priority pumping	Equal sharing of export capacity under SWRCB D-1641, USFWS BO (December 2008), and NMFS BO (June 2009) export restrictions9
Water transfers	Acquisitions by SWP contractors are wheeled at priority in Banks PP over non-SWP users; LYRA included for SWP contractors13
Sharing of export capacity for lesser priority and wheeling-related pumping	Cross Valley Canal wheeling (max of 128 TAF/year), CALFED ROD defined Joint Point of Diversion (JPOD)
San Luis Reservoir	San Luis Reservoir is allowed to operate to a minimum storage of 100 TAF

Table 2-1. CalSim II Modeling Assumptions (contd.)

	No Action Alternative[1]
CVPIA 3406(b)(2)	
Policy decision	May 2003 Department of Interior decision
Allocation	800 TAF/year, 700 TAF/year in 40-30-30 dry years, and 600 TAF/year in 40-30-30 critical years
Actions	Pre-determined non-discretionary USFWS BO (December 2008) upstream fish flow objectives (October-January) for Clear Creek and Keswick Dam, non-discretionary NMFS BO (June 2009) actions for the American and Stanislaus Rivers, and USFWS BO (December 2008) and NMFS BO (June 2009) actions leading to export restrictions[9]
Accounting adjustments	No discretion assumed under USFWS BO (December 2008) and NMFS BO (June 2009)[9], no accounting
WATER MANAGEMENT ACTIONS	
Water Transfer Supplies (long term programs)	
LYRA[13]	Yuba River acquisitions for reducing impact of NMFS BO export restrictions[9] on SWP
Phase 8	None
Water Transfers (short term or temporary programs)	
Sacramento Valley acquisitions conveyed through Banks PP	Post-analysis of available capacity[18]

Notes:

[1] These assumptions were initially developed under the direction of the DWR and Reclamation management team for the BDCP HCP and EIR/EIS. Additional modifications were made by Reclamation and DWR for subsequent planning studies, the most recent of which are the Reclamation 2015 Remand EIS Baseline, the DWR 2015 Delivery Capability Report, and draft studies for the Los Vaqueros Expansion Investigation (not released yet).

[2] The Sacramento Valley hydrology used in Future Condition CalSim-II models reflects 2020 land-use assumptions associated with Bulletin 160-98. The San Joaquin Valley hydrology reflects draft 2030 land-use assumptions developed by Reclamation to support Reclamation studies.

[3] CVP contract amounts have been reviewed and updated according to existing and amended contracts, as appropriate.

[4] SWP contract amounts have been updated as appropriate based on recent Table A transfers/agreements.

[5] Water needs for Federal refuges have been reviewed and updated, as appropriate. Refuge Level 4 (and incremental Level 4) water is not included.

[6] The Sacramento Area Water Forum agreement, its dry year diversion reductions, Middle Fork Project operations and "mitigation" water is not included.

[7] The newest CalSim-II representation of the San Joaquin River has been included in this model package (CalSim-II San Joaquin River Model, Reclamation, 2005). The model reflects the difficulties of ongoing groundwater overdraft problems. The 2030 level of development representation of the San Joaquin River Basin does not make any attempt to offer solutions to groundwater overdraft problems. In addition, a dynamic groundwater simulation is not yet developed for the San Joaquin River Valley. Groundwater extraction/recharge and stream-groundwater interaction are static assumptions and may not accurately reflect a response to simulated actions. These limitations should be considered in the analysis of result

[8] The CalSim-II model representation for the Stanislaus River does not necessarily represent Reclamation's current or future operational policies. A suitable plan for supporting flows has not been developed for NMFS BO (June 2009) Action III.1.3.

[9] In cooperation with NMFS, USFWS, and CDFW, the Reclamation and DWR have developed assumptions for implementation of the USFWS BO (December 15, 2008) and NMFS BO (June 4, 2009) in CalSim-II.

[10] Demand forecasts are derived from CCWD's Future Water Supply Study (CCWD, August 1996), with adjustments made for the future condition to estimate the demand distribution in 2030. Future condition demands represent Service Area C. Demands and demand pattern taken from April 2004 Planning Report. Water supplies are 195 TAF/yr CCP contract, water rights for Delta excess flows, and transfers.

Table 2-1. CalSim II Modeling Assumptions (contd.)

Notes: (contd.)

[11] Under existing conditions it is assumed that SWP Contractors demand for Table A allocations vary from 3.0 to 4.1 MAF/year. Under the Future No-Action baseline, it is assumed that SWP Contractors can take delivery of all Table A allocations and Article 21 supplies. Article 56 provisions are assumed and allow for SWP Contractors to manage storage and delivery conditions such that full Table A allocations can be delivered. Article 21 deliveries are limited in wet years under the assumption that demand is decreased in these conditions. Article 21 deliveries for the NBA are dependent on excess conditions only, all other Article 21 deliveries also require that San Luis Reservoir be at capacity and that Banks PP and the California Aqueduct have available capacity to divert from the Delta for direct delivery.

[12] The current USACE permit for Banks Pumping Plant allows for an average diversion rate of 6,680 cfs in all months. Diversion rate can increase up to 1/3 of the rate of San Joaquin River flow at Vernalis from Dec. 15th to Mar. 15th, up to a maximum diversion of 8,500 cfs, if Vernalis flow exceeds 1,000 cfs.

[13] Acquisitions of Component 1 water under the LYRA, and use of 500 cfs dedicated capacity at Banks PP during July–September, are assumed to be used to reduce as much of the impact of the April-May Delta export actions on SWP Contractors as possible.

[14] The CCWD Alternate Intake Project (also known as Middle River Intake Project), an intake at Victoria Canal, which operates as an alternate Delta diversion for Los Vaqueros Reservoir. Construction was completed in Fall of 2010.

[15] Delta actions, under USFWS discretionary use of CVPIA 3406(b)(2) allocations, are no longer dynamically operated and accounted for in the CalSim-II model. The Combined OMR flow and Delta export restrictions under the USFWS BO (December 15, 2008) and the NMFS BO (June 4, 2009) severely limit any discretion that would have been otherwise assumed in selecting Delta actions under the CVPIA 3406(b)(2) accounting criteria. Therefore, it is anticipated that CVPIA 3406(b)(2) account availability for upstream river flows below Whiskeytown, Keswick, and Nimbus dams would be very limited. It appears the integration of BO RPA actions will likely exceed the 3406(b)(2) allocation in all water year types. For these baseline simulations, upstream flows on the Clear Creek and Sacramento River are predetermined, based on CVPIA 3406(b)(2) based operations from the August 2008 BA Study 7.0 and Study 8.0 for Existing and Future No-Action baselines, respectively. The procedures for dynamic operation and accounting of CVPIA 3406(b)(2) are not included in the CalSim-II model.

[16] D-1644 and the LYRA are assumed to be implemented for existing and future conditions. The Yuba River is not dynamically modeled in CalSim-II. Yuba River hydrology and availability of water acquisitions under the LYRA are based on modeling performed and provided by the LYRA EIS/EIR study team.

[17] The model operates the Stanislaus River using a 1997 Interim Plan of Operation-like structure, i.e., allocating water for Stockton East Water District and CSJWCD, Vernalis water quality dilution, and Vernalis D-1641 flow requirements based on the New Melones Index. Oakdale Irrigation District and South San Joaquin Irrigation District allocations are based on their 1988 agreement and Ripon DO requirements are represented by a static set of minimum instream flow requirements during June thru Sept. Instream flow requirements for fish below Goodwin are based on NMFS BO Action III.1.2. NMFS BO Action IV.2.1's flow component is not assumed to be in effect.

[18] Only acquisitions of Lower Yuba River Accord Component 1 water included.

Key: % = percent
BO = Biological Opinion
CCWD = Contra Costa Water District
cfs = cubic feet per second
CSJWCD = Central San Joaquin Water Conservation District
CVP = Central Valley Project
CVPIA = Central Valley Project Improvement Act
D-1641 = SWRCB Water Right Decision Number D-1641
DMC = Delta-Mendota Canal
EBMUD = East Bay Municipal Utilities District
EIS = Environmental Impact Statement
FERC = Federal Energy Regulatory Commission
FRSA = Feather River service area
KCWA = Kern County Water Agency
LYRA = Lower Yuba River Accord
mgd = million gallons per day
NMFS = National Marine Fisheries Service
PP = power plant
SWP = State Water Project
SWRCB = State Water Resources Control Board
TAF = thousand acre feet

Action Alternatives

Methodology and Assumptions for Flow Augmentation Common to Both Action Alternatives

The Klamath, California gage (U.S. Geological Service (USGS) Gage 11530500) does not have a complete historical record that coincides with CalSim II, which evaluates operations from 1922 to 2003. To assess the potential flow augmentation operations required under the action alternatives, a long-term daily data set of the Klamath River at Klamath – consistent with the CalSim II period of analysis – is required. A long-term daily flow data set was needed to determine the duration, magnitude, and frequency of flow augmentation activities based on

identified criteria for preventive base flow augmentation, preventive pulse flows, and emergency pulse flow augmentation. As a complete historical record was not available, a long-term daily flow data set was developed based upon available flow records and adjusted for operational considerations (e.g., current biological opinions, historic Copco Dam operations) and climate change.

Development of Hydrology Used in Determining Augmentation Quantities Including Klamath Climate Change

Flow in the lower Klamath River is largely influenced by contributions from both the Klamath and Trinity Rivers. Identified flow records considered in this analysis are shown in Figure 2-2 and the temporal availability of these flow records is provided in Table 2-2.

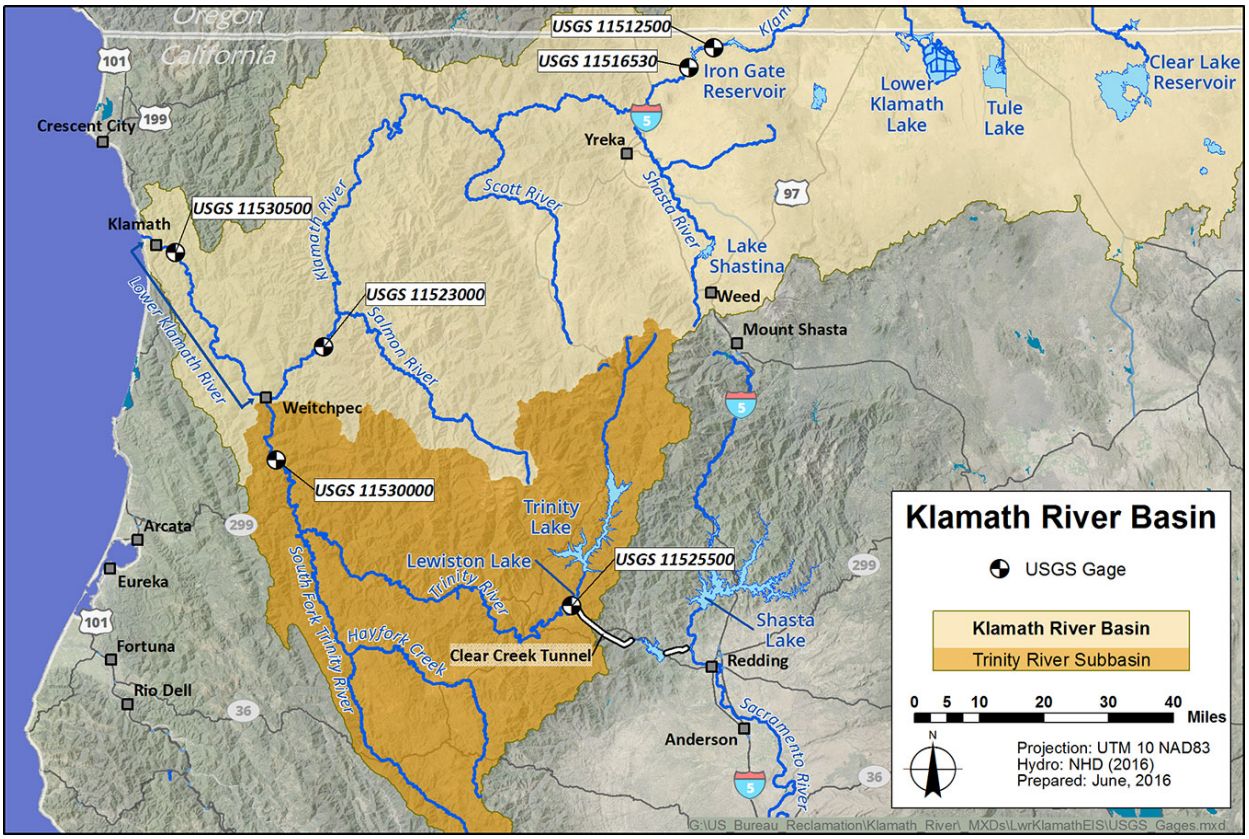


Figure 2-2. USGS Gages Utilized in Developing the Long-term Daily Hydrology for the Klamath River at Klamath, California

Table 2-2. USGS Gages Utilized in Developing the Long-term Daily Hydrology for the Klamath River at Klamath, California

Gage	Time Periods
USGS # 11530500 KLAMATH R NR KLAMATH CA	1911-1926, 1951-1995, 1998-2015
USGS # 11523000 KLAMATH R A ORLEANS	1928-2015
USGS # 11516530 KLAMATH R BL IRON GATE DAM	1960-2015
USGS # 11512500 KLAMATH R BL FALL C NR COPCO CA	1923-1961
USGS # 11530000 TRINITY R A HOOPA CA	1932-2015
USGS # 11525500 TRINITY R A LEWISTON CA	1911-2015

After review of historical flow data from these flow gages, as well as other flow gages in the Klamath and Trinity River basins, the period of analysis was reduced to August, September, and October to focus on the period when augmentation is expected to occur (i.e., when operations at Trinity Reservoir and releases at Lewiston Dam would be modified). The assumptions and process of developing the hydrology used in determining augmentation are described below.

Development and Application of Filter for Copco Hydropower Operations After 1961, Iron Gate Dam regulated hydropower discharges into the Klamath River. Prior to 1961, lower Klamath River flows were influenced by Copco Dam hydropower operations when Copco powerhouse was taken off line for maintenance, generally on a weekly basis. This maintenance activity manifested itself in the hydrologic signal as a one to three day marked decrease in flow. These deviations, from an otherwise generally stable flow condition, were removed by a forward looking algorithm that used either one, two, or three days of flow data, and then averaged flows before and after this short duration decrease. The original USGS data and the filtered daily time series for 1951 for the Klamath River at Orleans are shown in Figure 2-3. The hydropower operations are clearly apparent at approximately weekly intervals, and the filtered time series effectively represents the seasonal flow conditions. Similar conditions also existed for the Klamath River at Klamath.

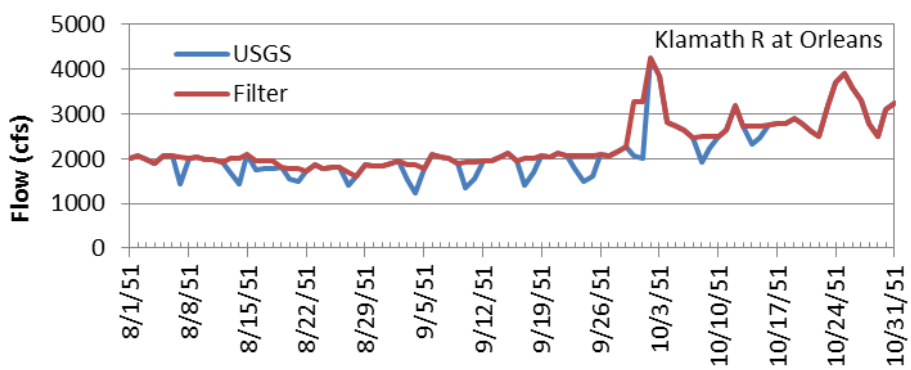


Figure 2-3. USGS Data and Filtered Time Series for Flow in the Klamath River at Orleans, 8/1/1951 to 10/31/1951

Filtered flows were limited to those below 3,000 cubic feet per second (cfs) for the Klamath River at Klamath gage and below 2,500 cfs for the Klamath River at Orleans gage. These targeted flows are of similar magnitude to the preventive base flow augmentation rate of 2,800 cfs, and minimized the filtering of flows due to rainfall-runoff events. Further, only decreases in one, two or three day flows greater than 400 cfs for the Klamath River at Klamath gage and greater than 200 cfs for the Klamath River at Orleans gage were filtered. These values were arrived at through a trial and error approach in order to filter out the maximum number of hydropower operations from the original USGS signal.

This filtering process resulted in overall increased flow in the system (represented by the area below the filtered time series (red line) and above the original USGS data (blue line) in Figure 2-2). To effectively conserve mass, the difference between the two time series was calculated on a daily basis and averaged over the August 1 to October 31 period, then subtracted from each daily value (see Figure 2-4).

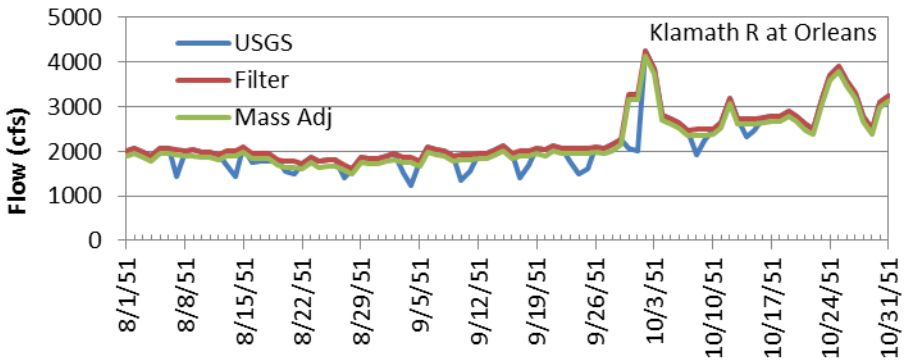


Figure 2-4. USGS data, Filtered Time Series, and Mass Adjusted Filtered Time Series for Flow in the Klamath River at Orleans, 8/1/1951 to 10/31/1951

These filtered data were subsequently used to:

a) Smooth USGS measured flows for the Klamath River at Klamath gage from 1922 to 1926, and from 1950 to 1961 – periods when data were available for this gage.

b) Develop regression equations to extend the record for the Klamath River at Klamath gage for periods where data were unavailable (1928 to 1950 and 1996 to 1997).

After 1961, Klamath River at Klamath gage flows were used directly, except for the periods noted above.

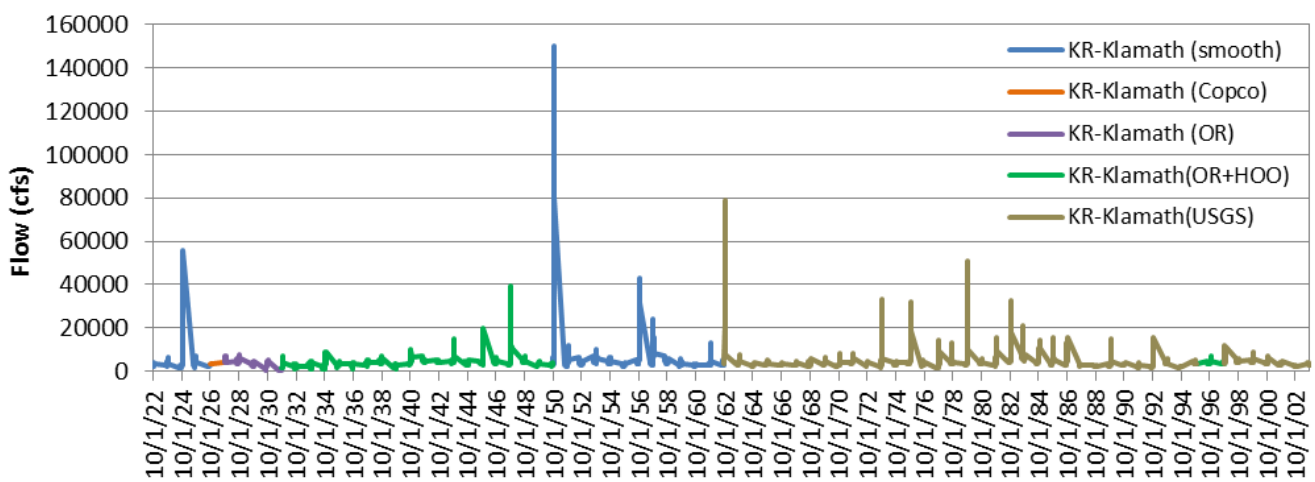
Development of Daily Flow Data for Missing Periods of Record Based on Statistical Relationships As identified in Table 2-2, historic daily flow data were available in the identified analysis period (i.e., 1922 to 2003) for the Klamath River at Klamath, California from 1922 to 1926, 1951 to 1995, and 1998 to 2003. Missing periods included 1927 to 1950, and 1996 to 1997. Regressions developed using available records from the Klamath River at Orleans and the Trinity River at Hoopa gages were utilized to develop all unavailable data except 1927 (which was developed using a relationship with flow data from the Klamath River below Fall

Creek near Copco) (Reclamation 2016a). Constraining the analysis to the three month period of August – October reduces the range of potential flows experienced during the winter and spring months when flows varied dramatically, ultimately yielding improved regression models. The data used in the development of the complete hydrology utilized for developing augmentation flows is presented in Table 2-3, as well as graphically in Figure 2-5.

Table 2-3. USGS Gages Used in Developing the Long-term Daily Hydrology for the Klamath River at Klamath, California

Period	Data Source	Notes
1922 – 1926	Klamath River at Klamath	Corrected for Copco hydropower signal
1927	Function of Klamath River below Fall Creek near Copco	
1928 – 1931	Function of Klamath River at Orleans	
1932 – 1950	Function of Klamath River at Orleans and Trinity River at Hoopa	
1951 – 1961	Klamath River at Klamath	Corrected for Copco hydropower signal
1962 – 1996	Klamath River at Klamath	
1997	Function of Klamath River at Orleans and Trinity River at Hoopa	
1998 – 2003	Klamath River at Klamath	

Key:
USGS = U.S. Geological Service



Key:
BO = Biological Opinion
cfs = cubic feet per second
KR-Klamath = Flow at Klamath River at Klamath (cfs)
ROD = Record of Decision

Figure 2-5. Derived Daily Time Series of Flows at Klamath River at Klamath (Without Adjustments for the Trinity River ROD, Klamath Project BO, and climate change): August to October Flows for 1922 to 2003

Modification of Long-Term Flow Data to Account for Trinity River Record of Decision and Klamath Project Biological Opinion Following development of the daily time series, additional modifications were required to reflect current operational requirements for Trinity River Division of the CVP and the Klamath Project. Specifically, minimum flow requirements identified in the Trinity River Record of Decision (ROD) and Klamath Project Biological Opinion (BO) – those flows that would have occurred if these operations had been in place for the 1922 to 2003 period – were incorporated.

Modification for Trinity River ROD Trinity River ROD minimum flow requirements were accommodated by comparing the historical daily flows in the Trinity River at Lewiston (USGS gage 11525500; uninterrupted record available from 1922 to 2003) with specified release requirements. The Trinity River ROD requires minimum releases from Lewiston Reservoir of 450 cfs in August and September and 300 cfs in October. When historical flows below Lewiston Dam were larger or smaller than these ROD flows, an adjustment was made to the developed flow at Klamath River at Klamath corresponding to the aforementioned difference between daily historical Lewiston release and the Trinity ROD requirement. If applicable, daily adjustments for the Klamath River at Klamath were offset by two days to account for travel time between Lewiston Dam and the Klamath gage. For example, if historical release from Lewiston Dam on September 7 was 400 cfs, developed flow at Klamath River at Klamath was adjusted up by 50 cfs on September 9. Trinity Reservoir storage was presumed to be sufficiently large to meet either increased releases (if historic flows were less than the specified Trinity River ROD flow) as well as accommodate increased storage (if flows are greater than the specified Trinity River ROD flows).

Modification for Klamath Project BO Klamath Project BO minimum flow requirements were assessed at Iron Gate Dam in a manner similar to the Trinity River ROD minimum flow requirements at Lewiston Dam. The Klamath Project BO requires minimum flows below Iron Gate Dam of 900 cfs in August and 1,000 cfs September. In this analysis, when historical flows were lower than these required minimums below Iron Gage Dam, an adjustment was made to the developed flow at Klamath River at Klamath corresponding to the aforementioned difference between daily historical flows below Iron Gate Dam and the Klamath Project BO requirements. For example, if historical flow below Iron Gate Dam was 750 cfs on August 1, developed flows at Klamath River at Klamath were adjusted up by 150 cfs. When historical flows below Iron Gate Dam were greater than the Klamath Project BO flow requirements, no action was taken (i.e., flows were not reduced and assumed to not be stored in mainstem reservoirs). This assumption was made because mainstem Klamath storage is limited, unlike storage availability in Trinity Reservoir on the Trinity River during this time of year (e.g., late summer/early fall).

A key consideration for Iron Gate Dam is the lack of a continuous flow record. For the period 10/1/1960 to 9/30/2003, the USGS gage for the Klamath River below Iron Gate Dam (USGS gage 11516530) was used to adjust flows to accommodate the Klamath Project BO minimum flow requirements. Due to limited relevant available data, Klamath River at Orleans gage data (USGS gage 11523000) were used to adjust flows to accommodate Klamath Project BO minimum flow requirements for the period of 10/1/1927 to 9/30/1960. For the period of 10/1/1922 to 9/30/1927, no relevant flow records were available and no adjustments were made.

Modification of Long-Term Flow Data to Account for Climate Change To adjust the daily flow data to reflect potential climate change, results of two Reclamation studies were considered, including climate change studies in support of the Secretarial Determination for Klamath Dam Removal and the on-going Klamath Basin Study. The Klamath Dam Removal climate change scenarios reflect a future time horizon of 2045 (2020-2069) (see Reclamation 2011). Five specific climate scenarios were selected based on their proximity to the vertices of the 25th, 50th, and 75th quartiles of the empirical distributions of precipitation and temperature. Klamath Basin Study climate change scenarios reflect a future time horizon of the 2030's (2020-2049). Central tendency scenarios were developed using a hybrid ensemble delta method, selecting 10 GCM projections as ensemble members that are closest to the intersections of the 50th percentile values of projected change in annual precipitation and temperature. Scenarios developed from both CMIP3 and Coupled Model Intercomparison Project Phase 5 (CMIP5) data sets have been examined for this analysis.

To develop daily flow time series for each climate change scenario, the following process was used:

- Calculated monthly regressions for perturbed flow as a function of historical or current condition flow for both Klamath Dam Removal (5 scenarios) and Klamath Basin Study (2 scenarios) climate change results.

- Calculated monthly average flows for the derived daily time series at Klamath River at Klamath gage.

- Applied the regressions to the derived time series' monthly flows to derive climate-perturbed monthly flow.

- Disaggregated the perturbed monthly flows reflecting climate change back to daily flows through application of the daily pattern in the historical trace.

It is acknowledged that this methodology lacks the additional step of adjusting by an annual perturbation factor. This was not possible, as the derived daily time series data were developed solely to address augmentation needs in August, September and October.

Table 2-4 presents estimated preventive base flow augmentation requirements for the derived daily time series, two climate change scenarios from the Klamath Dam Removal studies, and two climate change scenarios from the on-going Klamath Basin Study. In addition, for comparative purposes, Table 2-4 also includes estimated preventive base flow augmentation requirements for the time period of 2002 to 2015, based on historical flows adjusted for actual flow augmentation and Trinity River ROD and Klamath BO minimum flow requirements.

Table 2-4. Summary of Preventive Base Flow Augmentation Requirements for Derived Daily Time Series and Climate Change Scenarios

Description	Derived Daily Time Series	KDR 37	KDR 24	KBS CT3	KBS CT5	2002-2015 Historical Data Corrected for Actual Augmentation, Klamath Project BO, and Trinity River ROD
Climate Change Timeframe	No climate change	2045	2045	2030's	2030's	No climate change
Period	1922-2003	1922-2003	1922-2003	1922-2003	1922-2003	2002-2015
# of Years of Flow Augmentation for CalSim Analysis [1]	38	62	69	48	53	-
Average - All Years (acre-feet) [1]	6,158	16,705	24,043	11,026	14,334	14,794
Average - Years with Flow Augmentation (acre-feet) [1]	13,287	22,093	28,573	18,837	22,178	19,232
Percentage of Years with Flow Augmentation [1]	46%	76%	84%	59%	65%	71%

Note:
[1] Based on preventive base flow augmentation criteria of 2,800 cubic feet per second at the Klamath, California gage from August 22 to September 21.
Key:
% = percent
BO = Biological Opinion
KDR = Klamath Dam Removal
KBS = Klamath Basin Study
ROD = Record of Decision

Development of Flow Augmentation Quantities

The action alternatives include three different flow augmentation components: (1) a preventive base-flow release that targets increasing the base flow of the lower Klamath River to 2,800 cfs from mid-August to late September; (2) a preventive pulse flow to be used as a secondary measure to alleviate continued poor environmental conditions and signs of *Ichthyophthirius multifiliis* (Ich) infection in the lower Klamath River; and (3) a contingency volume, to be used on an emergency basis as a tertiary treatment to avoid a significant die-off of adult salmon when the first two components of the Proposed Action are not successful at meeting their intended objectives. Required augmentation was determined by evaluating developed representative daily flows at the Klamath River at Klamath against the 2,800 cfs flow target.

During the base-flow augmentation period of August 22 – September 21, if representative daily flows were less than 2,800 cfs, it was determined that a flow augmentation equal to the difference between the representative daily flow and 2,800 cfs was required (e.g., if representative flow on August 22 was 2,500 cfs, a flow augmentation of 300 cfs was required). A two day travel time from Lewiston to the Klamath River at Klamath was assumed; therefore, if representative flow on August 22 was 2,500 cfs, a flow augmentation of 300 cfs was required on August 20. This analysis was applied to the augmentation period for every water year in the

CalSim II period of analysis. The resulting base-flow augmentation quantities are presented with pulse flow quantities in the "Input to CalSim" section below.

During the preventive pulse flow period, a preventive pulse flow of 5,000 cfs for one day was targeted in the representative daily Klamath River at Klamath flow record. Ramping rates from Trinity River Mainstem Fisheries Restoration EIS (USFWS et al. 2000) were targeted to develop the preventive pulse flow requirements. If daily representative Klamath River at Klamath flows were less than the preventative pulse flow or required ramping up/down rates, it was determined that a preventive pulse flow augmentation equal to the difference between the representative daily flow and the pulse flow or ramping up/down rate requirements was required (e.g., if representative flow on the day of the targeted preventative pulse flow was 2,500 cfs, a preventative pulse flow augmentation of 2,500 cfs was required). A two day travel time from Lewiston to the Klamath River at Klamath was assumed for releasing flows to meet pulse flow requirements.

During the emergency pulse flow period, an emergency pulse flow of 5,000 cfs for five days was targeted in the representative daily Klamath River at Klamath flow record. Ramping rates from Trinity River Mainstem Fisheries Restoration EIS (USFWS et al. 2000) were also targeted in meeting the emergency pulse flow requirements. If daily representative Klamath River at Klamath flows were less than the emergency pulse flow or required ramping up/down rates, it was determined that an emergency pulse flow augmentation equal to the difference between the representative daily flow and the pulse flow or ramping up/down rate requirements was required (e.g., if representative flow on the day of the targeted emergency pulse flow was 2,500 cfs, an emergency pulse flow augmentation of 2,500 cfs was required). A two day travel time from Lewiston to the Klamath River at Klamath was assumed for releasing flows to meet pulse flow requirements.

Frequency and Timing of Pulse Flow Quantities

Implementing pulse flow analyses into CalSim II modeling required a means of determining the impacts of using different water sources for flow augmentation actions as described for each alternative. In order to do these assessments, there is a need to define the frequency of implementing the preventive pulse and emergency flow components of the action alternatives.

Period of Frequency Analysis The potential frequency-of-occurrence of the preventive pulse and emergency components were derived from review of the years in which augmentation actions occurred since the year of the die-off (Reclamation 2016b). As such, the analysis looks at a total of 14 years (i.e., 2002 to 2015) and characterizes the actions actually taken, as well as retroactively looks at the actions that could have been taken given the criteria upon which these two components of the action alternatives are based. For purposes of the analysis, it is assumed that 2002 would have been a year in which all three components (i.e., preventive base, preventive pulse flow, and emergency flows) would have been implemented. While it is unknown how implementation of these components would have influenced the outcome of that year, they were included in this review because of the extreme environmental conditions that came together to cause the unprecedented adult salmon die-off in that year.

Preventive Pulse Flow Frequency Determination The preventive pulse flow was determined to only be implemented in a subset of the years when the preventive base flow was implemented.

In addition, it was recognized that that there would not likely be a need for this pulse flow in every year that a base flow augmentation occurred because the criteria for implementing a preventive pulse flow would not have been met in every year. It appears appropriate to anticipate that in some flow augmentation years the preventive base flow would be adequate to thwart the need for this secondary response action. With this in mind, existing Ich monitoring results for the lower Klamath River (Yurok Tribe Ich monitoring data) were examined for each year that a flow augmentation release occurred (i.e., 2003, 2004, 2012 – 2015) and for three additional years that would have met the primary base flow action criteria (2007, 2008, and 2009; see Table 2-5). Using this approach, three years (i.e., 2003, 2014, and 2015) were identified when a preventive pulse flow would likely have been implemented because the threshold for low level infection and other criteria are anticipated to have been met. When including 2002 as a year that a preventive pulse would likely have been needed, 4 of 10 years (i.e., 40 percent of the time there is a preventive base flow augmentation) would have required a preventive pulse flow (See Table 2-6 in the section below).

Table 2-5. Ich Monitoring Results for Years When Flow Augmentation Actions Occurred (or Would Have Occurred Under the Action Alternatives)

Augmentation Year	**Ich Counts[d]**	**Preventive Pulse Triggered (Y/N)**	**Data Source**
2002[a]	Likely	Y	Guillen (2003); DFG (2003); YTFP (2004)
2003	Counts > 50 observed; weekly average as high as 24/gill arch	Y	Foott (2003)
2004[b]	0[b]	N	YTFP (2005)
2007	0	N	YTFP (2008)
2008	0	N	YTFP (2009)
2009	0	N	YTFP (2010)
2012	0	N	YTFP (2013)
2013	0	N	YTFP (2014)
2014	Counts > 600 observed	Y	YTFP (2015)
2015[c]	Average counts > 20 week of Aug 17. Max counts > 600	Y	YTFP (In progress); CDFW 2016
Events		4	
Sample size		10	
Frequency (%)		40	

Notes:
[a] assumption made that Ich counts would have met the criterion
[b] 2004 monitoring mentioned in a Yurok Tribe report on 2005 monitoring, but full 2004 results not reported.
[c] the first year that a preventive pulse flow was formally implemented
[d] Counts are qualified by criteria as defined by Reclamation (2015b), where low level infection (less than 30 Ich trophonts per gill arch) occur in the first two weeks of September on three adult salmon in one day.
Key: % = percent
CDFW = California Department of Fish and Wildlife (formerly California Department of Fish and Game)
DFG = California Department of Fish and Game
YTFP = Yurok Tribe Fisheries Program

Emergency Pulse Flow Frequency Determination The emergency flow was determined to only be implemented in years when the preventive pulse flow was implemented. Again, the same logic was used (as for the preventive pulse flow); that is, a successive level of treatment would be implemented only if the prior treatment is used and not successful. Using this logic, the emergency pulse flow was anticipated to be used when the preventative pulse flow was not effective. To determine the frequency of need, the years when emergency releases were used (i.e., 2014) were considered. 2002 was also chosen, due to the assumption that the large adult salmon die-off would have necessitated emergency pulse flow releases. Using this information, 2 of 10 years (i.e., 20 percent of the time there is a preventive pulse flow) would have required an emergency pulse flow release (see Table 2-6).

Table 2-6. Actual and Projected Occurrence of Preventive Pulse and Emergency Flow Actions Based on Prior Flow Augmentation Years (2003, 2004 and 2012 – 2015)

Augmentation Year	Actual Preventive Pulse Flow (Y/N)	Actual Emergency Pulse Flow (Y/N)	Retroactive Preventive Pulse Flow (Y/N)	Retroactive Emergency Pulse Flow (Y/N)
2002[a]	N	N	Y	Y
2003	Y	N	Y	N
2004	Y	N	N	N
2007	N	N	N	N
2008	N	N	N	N
2009	N	N	N	N
2012	N	N	N	N
2013	N	N	N	N
2014	Y	Y	Y	Y
2015	Y	N	Y	N
Events	4	1	4	2
Sample Size	10	10	10	10
Frequency	**40%**	**10%**	**40%**	**20%**

Note:
[a] Assume criteria for Preventive Pulse Flow and Emergency pulses would have been met in 2002
Key:
% = percent

Input to CalSim

The analysis of need for base flow augmentation resulted in the identification of 53 years of preventive base flow augmentation out of the 82 year period of record (Reclamation 2016c). Based on the above frequency of pulse flows analysis, an estimated 21 years of preventive pulse flows and an estimated 4 years of emergency pulse flow augmentation would occur over the 82 year period of record.

The criteria for implementing preventive pulse flows and emergency pulse flow augmentation actions are based upon observed fish health (i.e., Ich counts). However, analytical tools to predict fish health are not readily available for this analysis. Table 2-7 provides the estimated base flow augmentation volume, based upon the criteria identified for the action alternatives in this EIS, as well as the corresponding estimated occurrences of preventive pulse flows and emergency pulse flow augmentation. As shown in Table 2-7, the years with the largest estimated base flow augmentation generally were associated with years where both preventive pulse flows and

emergency pulse flow augmentation occurred. For example, the three years with the largest estimated flow augmentation (i.e., 2014, 2015, and 2002) were also years with identified preventive pulse flows. Similarly, 2014 and 2002 were the only two years with identified emergency pulse flow augmentation and these two years also required the highest and third highest preventive base flow augmentation quantities, respectively.

Table 2-7. Retroactive Augmentation Summary (2002-2015)

Year	Preventive Base Flow Augmentation[1] (acre-feet)	Actual Augmentation Volume (acre-feet)	Retroactive – Preventive Pulse Flow[2]	Retroactive – Emergency Pulse Flow Augmentation[2]
2014	42,920	64,000	Yes	Yes
2015	37,313	48,000	Yes	-
2002	34,657	-	Yes	Yes
2009	25,460	-	-	-
2013	21,213	17,500	-	-
2007	11,197	-	-	-
2008	8,025	-	-	-
2004	4,804	36,313	-	-
2012	4,330	39,000	-	-
2003	2,400	38,000	Yes	-
2005	-	-	-	-
2006	-	-	-	-
2010	-	-	-	-
2011	-	-	-	-

Notes:

[1] Based on historical flow data (excluding climate change) at Klamath, California with preventive base flow criteria of 2,800 cubic feet per second from August 22 through September 21.

[2] Based on findings from Frequency of Action Analysis: Preventive Pulse and Emergency Flows Technical Memorandum (Reclamation 2016c).

For the purposes of CalSim modeling and based on the findings in Table 2-6, preventive pulse flows were assumed to occur in the 21 years with the 21 highest preventive base flow augmentation quantities. Similarly, emergency pulse flow augmentation was assumed to occur in the four years with the four highest preventative base flow augmentation quantities. These assumptions and quantities are summarized in Table 2-8, Table 2-9, and Figure 2-6.

Table 2-8. Summary of Preventative Base Flow Augmentation, Preventive Pulse Flow and Emergency Pulse Flow Augmentation Volume by Water Year

Water Year	Preventive Base Flow Augmentation (acre – feet)	Preventive Pulse Flow Augmentation (acre-feet)	Emergency Pulse Flow Augmentation (acre-feet)	Total Augmentation (acre-feet)
1922	25,860	7,271	-	33,131
1923	6,555	-	-	6,555
1924	26,161	7,271	-	33,432
1925	22,487	-	-	22,487
1926	27,369	7,271	-	34,640
1927	-	-	-	-
1928	-	-	-	-
1929	-	-	-	-
1930	31,775	4,990	-	36,765
1931	91,693	7,271	45,419	144,383
1932	42,359	7,271	-	49,630
1933	6,209	-	-	6,209
1934	42,658	7,271	-	49,929
1935	12,020	-	-	12,020
1936	5,816	-	-	5,816
1937	1,863	-	-	1,863
1938	-	-	-	-
1939	17,538	-	-	17,538
1940	-	-	-	-
1941	-	-	-	-
1942	-	-	-	-
1943	-	-	-	-
1944	-	-	-	-
1945	-	-	-	-
1946	-	-	-	-
1947	-	-	-	-
1948	-	-	-	-
1949	14,293	-	-	14,293
1950	2,919	-	-	2,919
1951	27,315	7,271	-	34,586
1952	-	-	-	-
1953	-	-	-	-
1954	-	-	-	-
1955	11,124	-	-	11,124
1956	-	-	-	-
1957	-	-	-	-
1958	-	-	-	-
1959	76	-	-	76
1960	13,666	-	-	13,666
1961	316	-	-	316
1962	5,660	-	-	5,660
1963	7,354	-	-	7,354
1964	30,283	7,271	-	37,554
1965	242	-	-	242
1966	21,814	-	-	21,814
1967	20,408	-	-	20,408
1968	22,496	-	-	22,496
1969	15,207	-	-	15,207

Table 2-8. Summary of Preventative Base Flow Augmentation, Preventive Pulse Flow and Emergency Pulse Flow Augmentation Volume by Water Year (contd.)

Year	Preventive Base Flow Augmentation (acre – feet)	Preventive Pulse Flow Augmentation (acre-feet)	Emergency Pulse Flow Augmentation (acre-feet)	Total Augmentation (acre-feet)
1970	27,736	7,271	-	35,007
1971	-	-	-	-
1972	7,436	-	-	7,436
1973	43,275	7,271	-	50,546
1974	7,886	-	-	7,886
1975	-	-	-	-
1976	2,911	-	-	2,911
1977	60,288	7,271	25,727	93,286
1978	-	-	-	-
1979	16	-	-	16
1980	-	-	-	-
1981	29,756	7,271	-	37,027
1982	-	-	-	-
1983	-	-	-	-
1984	-	-	-	-
1985	938	-	-	938
1986	9,354	-	-	9,354
1987	38,837	7,271	-	46,108
1988	50,965	7,271	-	58,236
1989	28,857	7,271	-	36,129
1990	17,611	-	-	17,611
1991	50,284	7,271	-	57,555
1992	51,790	7,271	-	59,061
1993	-	-	-	-
1994	67,787	7,271	39,378	114,437
1995	817	-	-	817
1996	216	-	-	216
1997	1,041	-	-	1,041
1998	-	-	-	-
1999	-	-	-	-
2000	31	-	-	31
2001	42,733	7,271	-	50,004
2002	56,811	7,271	39,034	103,116
2003	24,508	-	-	24,508

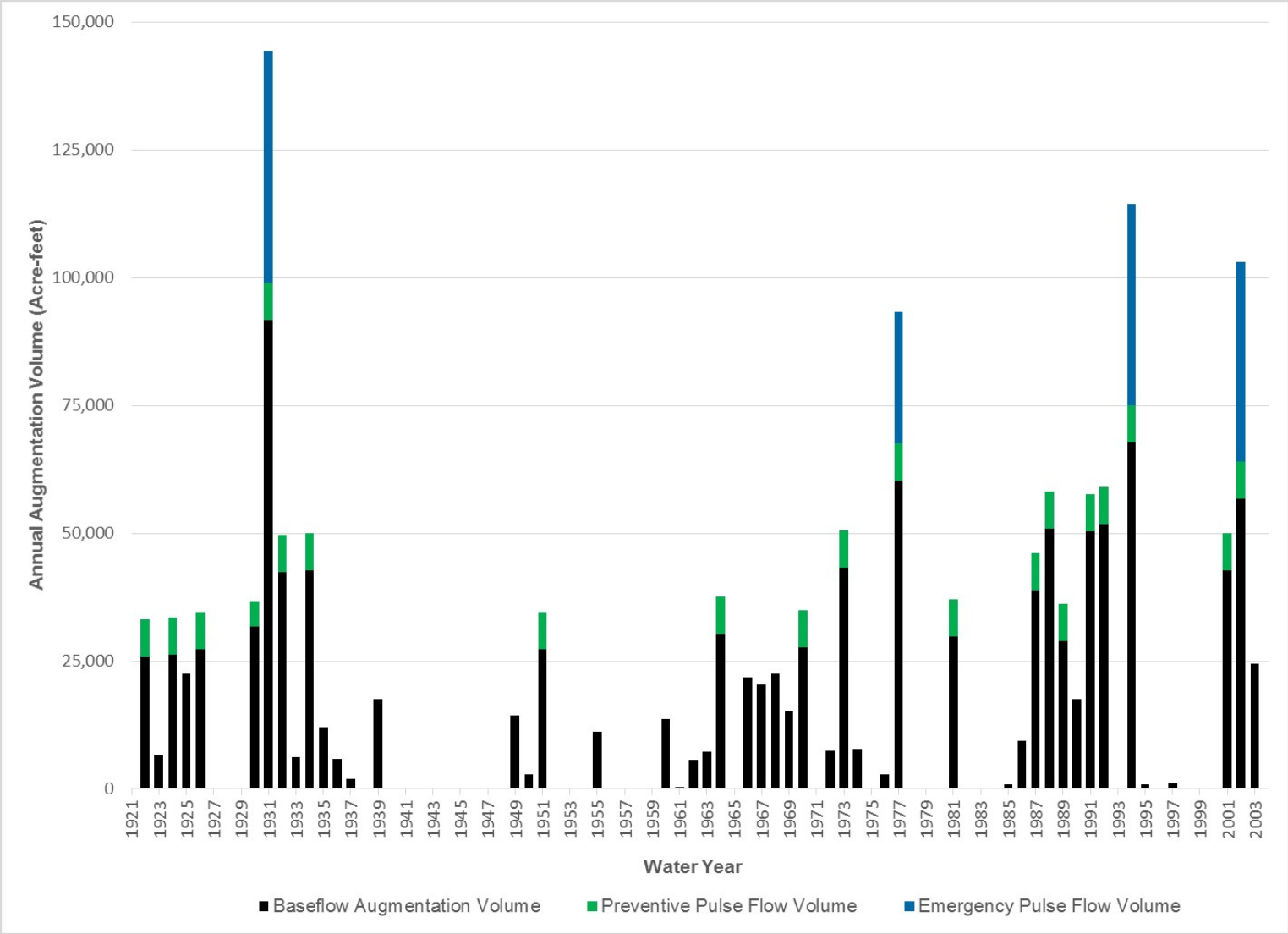


Figure 2-6. Estimated Flow Augmentation Volumes of Action Alternatives for the CalSim Period of Analysis

Table 2-9. Preventative Base Flow Augmentation for the 1922-2003 Period by Hydrologic Year Type

Critically Dry		**Dry**		**Normal**		**Wet**		**Extremely Wet**	
Year	**Preventive Base Flow Augmentation (acre-feet)**	**Year**	**Preventive Base Flow Augmentation (acre-feet)**	**Year**	**Preventive Base Flow Augmentation (acre-feet)**	**Year**	**Preventive Base Flow Augmentation (acre-feet)**	**Year**	**Preventive Base Flow Augmentation (acre-feet)**
1931	91,693	1992	51,790	2002	56,811	1973	43,275	2003	24,508
1994	67,787	1988	50,965	1989	28,857	1970	27,736	1969	15,207
1977	60,288	2001	42,733	1968	22,496	1951	27,315	1974	7,886
1991	50,284	1932	42,359	1966	21,814	1925	22,487	1995	817
1934	42,658	1987	38,837	1949	14,293	1967	20,408	1927	-
1924	26,161	1930	31,775	1960	13,666	1986	9,354	1938	-
1939	17,538	1964	30,283	1972	7,436	1963	7,354	1941	-
1923	6,555	1981	29,756	1936	5,816	1997	1,041	1942	-
1976	2,911	1926	27,369	1962	5,660	1965	242	1952	-
1929	-	1922	25,860	1937	1,863	1996	216	1956	-
1944	-	1990	17,611	1961	316	2000	31	1958	-
		1935	12,020	1959	76	1940	-	1978	-
		1955	11,124	1928	-	1946	-	1982	-
		1933	6,209	1943	-	1953	-	1983	-
		1950	2,919	1945	-	1954	-	1998	-
		1985	938	1948	-	1971	-		
		1979	16	1957	-	1975	-		
		1947	-			1980	-		
						1984	-		
						1993	-		
						1999	-		
# of Years	**Average Augmentation**	**# of Years**	**Average Augmentation**	**# of Years**	**Average Augmentation**	**# of Years**	**Average Augmentation**	**# of Years**	**Average Augmentation**
11	**33,261**	**18**	**23,476**	**17**	**10,536**	**21**	**7,593**	**15**	**3,228**

CalSim II Outputs

The hydrology and system operations models produce the following key parameters on a monthly time step:

- River flows and diversions
- Reservoir storage
- Delta flows and exports

- Delta inflow and outflow
- Deliveries to project and non-project users

Appropriate Use of CalSim II Results

CalSim II is a monthly model developed for planning level analyses. The model is run for an 82-year historical hydrologic period, at a projected level of hydrology and demands, and under an assumed framework of regulations. Therefore, the 82-year simulation does not provide information about historical conditions, but it does provide information about variability of conditions that would occur at the assumed level of hydrology and demand with the assumed operations, under the same historical hydrologic sequence. Because it is not a physically based model, CalSim II is not calibrated and cannot be used in a predictive manner. CalSim II is intended to be used in a comparative manner, which is appropriate for a NEPA analysis.

In CalSim II, operational decisions are made on a monthly basis, based on a set of predefined rules that represent the assumed regulations. The model has no capability to adjust these rules based on a sequence of hydrologic events such as a prolonged drought, or based on statistical performance criteria such as meeting a storage target in an assumed percentage of years.

Appropriate use of model results is important. Despite detailed model inputs and assumptions, the CalSim II results may differ from real-time operations under stressed water supply conditions. Such model results occur due to the inability of the model to make real-time policy decisions under extreme circumstances, as the actual (human) operators must do. Therefore, these results should only be considered an indicator of stressed water supply conditions under that alternative, and should not be considered to reflect what would occur in the future. For example, reductions to senior water rights holders due to dead-pool conditions in the model can be observed in model results under certain circumstances. These reductions, in real-time operations, may be avoided by making operational decisions on other requirements in prior months. In actual future operations, as has always been the case in the past, the project operators would work in real time to satisfy legal and contractual obligations given the current conditions and hydrologic constraints. Chapter 4, “Surface Water Resources and Water Supplies”, provides appropriate interpretation and analysis of such model results.

Reclamation’s 2008 LTO BA Appendix W (Reclamation 2008b) included a comprehensive sensitivity and uncertainty analysis of CalSim II results relative to the uncertainty in the inputs. The appendix provides a good summary of the key inputs that are critical to the largest changes in several operational outputs. Understanding the findings from the appendix may help in better understanding the alternatives.

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Chapter 3
Reservoir and River Temperature Modeling

The Trinity-Sacramento River HEC-5Q Water Quality Model was selected to simulate the water temperature in the Trinity Lake – Lewiston Reservoir section of the Trinity River and in the Sacramento River Basin.

Trinity-Sacramento River HEC-5Q Water Quality Model

The Trinity-Sacramento River HEC-5Q Water Quality Model is a HEC-5Q-based (one-dimensional) reservoir and river water quality and temperature model of the Trinity Upper Sacramento River system including Trinity Dam and Reservoir, Trinity River to Lewiston Reservoir, Lewiston Dam and Reservoir, Clear Creek Tunnel, Whiskeytown Dam and Reservoir, Clear Creek below Whiskeytown Dam, Spring Creek Tunnel, Shasta Dam and Reservoir, Keswick Dam and Reservoir, Sacramento River from Keswick to Knights Landing, Red Bluff Diversion Dam, Black Butte Dam, and downstream Stony Creek. The Trinity-Sacramento River HEC-5Q model was developed using integrated HEC-5 and HEC-5Q models. The HEC-5 component of the model simulates reservoir and river flow operations (usually daily). The HEC-5Q component is a 1-dimensional (1-D) water quality model that simulates reservoir and river temperatures and other water quality parameters based on the flow inputs and meteorological parameters. The model operates on a 6-hour time step to capture diurnal temperature fluctuations.

Application of Trinity-Sacramento River HEC-5Q Model to Evaluate EIS Alternatives

The version of this model used in the *Coordinated Long-Term Operation of the Central Valley Project and State Water Project (LTO) EIS* (Reclamation 2015) was obtained from Reclamation. This version of the model included recent updates, calibration and verification, and modified meteorological and equilibrium temperature data to incorporate the 2030 level of climate change required for this analysis, as described in the LTO EIS (Reclamation 2015). The model is set up to simulate the full CalSim II model 82-year simulation period (water years 1922 through 2003) on a 6-hour time step using daily flow data which includes a utility to disaggregate the mean monthly CalSim II reservoir operations and stream flows to daily values for use in the simulation. The 6-hour time step allows for analysis of diurnal temperature fluctuations required for the fishery analysis.

Modeling Assumptions

For each alternative, reservoir operations and resulting stream flows were disaggregated from the CalSim II monthly values to daily values using a utility program developed specifically for this purpose and included with the version of the model obtained from Reclamation. Each daily value was assumed equal to the mean monthly value for consistency with the Reclamation's 2015 LTO EIS.

The daily augmentation flows (Alternatives 1 and 2)and the modified Trinity ROD flows (Alternative 2 only) were averaged and converted to a mean monthly flow for use in the CalSim II simulation modeling as the required releases from Lewiston to the Trinity River. For the temperature modeling, the final CalSim II mean monthly release from Lewiston were disaggregated to daily flows using the daily augmentation pattern used to generate the mean monthly release requirement. These new daily flows were then used to replace the uniform daily flows at this location generated by the utility program.

Klamath and Trinity Rivers RBM10

River Basin Model 10 (RBM10) is a 1-D water temperature model based on a heat budget formulation to predict daily water temperatures along the longitudinal profile of a river (Yearsley et al. 2001, Yearsley 2009). The existing RBM10 models were used to simulate daily flows and water temperature in the Trinity River and the Klamath River. Both models used in the temperature modeling studies of Trinity River (Jones et al. 2016) and Klamath River (Perry et al. 2011) are calibrated and well documented.

The model utilizes a mixed Eularian-Lagrangian numerical scheme to assess flow and water temperature (Jones et al. 2016). Flow is a steady flow representation where inflows and outflows are represented through simple mass balance. Water temperature is solved using a Lagrangian frame of reference solving a simplified form of the advection-diffusion equation where diffusion is neglected:

$$\frac{dT}{dt} = \frac{1}{\rho C_p A_x}\left(W_x H_{\text{air-water}} + S_{\text{adv}}\right)$$

Where:

T = water temperature

t = time

r = water density

C_p = specific heat of water

A_x = stream cross sectional area at location x

$H_{air\text{-}water}$ = net heat flux at the air water interface

S_{adv} = heat contribution from tributary inflows

The river is represented by discrete segments, where each segment includes channel form information (e.g., stage-flow, velocity-flow, width-flow and cross sectional area-flow relationships). A heat budget formulation, represented by $H_{air\text{-}water}$ requires daily average meteorological data. Boundary conditions for flow and water temperature at the headwater and tributary locations are required. Specific details of the Trinity River and Klamath River RBM10 models are provided in Jones et al (2016) and Perry et al (2011), respectively.

Application of RBM10 to Evaluate EIS Alternatives

The Klamath River and the Trinity River models above were acquired from the USGS. These original models were based on "historic" conditions using field flow, temperature, and meteorological data. Simulations for all alternatives were performed for the period between 01/01/1980 and 09/30/2003 to overlap the CalSim II data set used in much of the EIS. The RBM10 models were run in series, with the Trinity River applied first to calculate flow and temperature conditions at the confluence with the Klamath River. Subsequently, these flows and temperature were used to represent the Trinity River inflows to the Klamath River RBM-10 model. The Klamath River RBM10 model starts at Link River Dam near Klamath Falls and extends to the Klamath River estuary.

While the majority of the model was unchanged, several model modifications were completed to align the modeling assumptions with the purpose of this project. Modification and refinements included adjusting meteorological terms to incorporate assumed climate change condition in the project area, calculating tributary inflow temperatures for both the Klamath and Trinity Rivers to reflect climate change, updating the Bowen Ratio factor calculation, and refining the accretion depletion term in the Trinity River flow model.

Meteorological Data

Climate change was incorporated into each simulation, creating an equal meteorological data set for each. Air temperature was increased 1.8 degree Fahrenheit (ºF) (1 ºC) for consistency with the LTO EIS (Reclamation 2015). Climate change impacts on hydrology were included in the simulated flows at Lewiston Dam through the Trinity-Sacramento River HEC-5Q Water Quality Model and CalSim II modeling. For the Trinity River and Klamath River RBM-10 models, meteorological conditions were modified by increasing air temperature 1.8ºF (1ºC). In addition to the air temperature increase, two terms in meteorological input files, i.e., vapor pressure term and factor for Bowen Ratio term were updated accordingly.

Equations 1 through 4 were used to predict future vapor pressure (Snyder and Shaw 1984):

$$e_s = 6.108\exp\left[\frac{17.27T}{T+237.3}\right] \quad (1)$$

$$e = \frac{RH \times e_s}{100} \quad (2)$$

$$D = 237.3B/(1-B) \quad (3)$$

$$\text{where } B = \ln(e/6.108)/17.27 \quad (4)$$

e_s : saturation vapor pressure (mb)

T: dry-bulb (air) temperature (ºC)

e: vapor pressure (mb)

RH: relative humidity (%)

D: dewpoint temperature (ºC)

It should be noted that there is no relative humidity input in the models' meteorological input file(s). For the current conditions, relative humidity values were calculated by using air temperature and vapor pressure inputs and the equations listed above. Climate change adjusted vapor pressure was calculated assuming relative humidity remains the same in the future.

To predict the future factor for Bowen Ratio, equations 5 and 6 were used.

$$R_B = (c_a P)/0.622 \cdot \lambda \quad (5)$$

where c_a : heat capacity of air (cal/g/ ºC), 0.24

P: pressure at the meteorological station (mb)

λ: latent heat of vaporization (cal/g)

$$\lambda = 597.3 - (0.564 \cdot T) \quad (6)$$

T: air temperature (ºC)

With the previously mentioned increase in air temperature, predictions of vapor pressure and factor for Bowen Ratio terms (i.e., the terms/meteorological inputs which are a function of air temperature) were adjusted for the effects of climate change. These climate change adjusted values were applied to the meteorological data for both the Klamath and Trinity River RBM10 models in each of the three alternatives.

Tributary Water Temperature

In addition to the predictions in meteorological conditions which are mentioned above, the tributary water temperatures were adjusted for climate change by updating the Mohseni relationships (Mohseni et al. 1998), originally developed by Jones (Jones et al. 2016) for the Trinity River and Perry (Perry et al. 2011) for the Klamath River by accounting for an increase in air temperature of 1.8ºF (1ºC). No change in volume or timing associated with climate change was incorporated into the tributary flow rates.

The documented Mohseni equation in the USGS study (Jones et al. 2016) was updated to represent the current USGS assumed equation to estimate the temperatures for the Trinity River tributaries for the historic conditions run/scenario and the alternatives. The Mohseni equation (Mohseni et al. 1998) takes the form,

$$T_s = \mu + \frac{\alpha - \mu}{1 + e^{\gamma(\beta - T_a)}} \quad (1)$$

where T_s: weekly mean water temperature (ºC)

μ: minimum water temperature (ºC)

α: maximum water temperature (ºC)

β: water temperature at the point of inflection (ºC)

γ: slope at the inflection point (ºC)

T_a: weekly mean air temperature (ºC).

The first "μ" term in Eq. (7) (prior to the fraction term) was excluded in the original USGS development of tributary temperatures in the Klamath and Trinity Rivers, and a new form (equation (Eq. 8)), was used to plot the graphs of the air temperature versus water temperature curves for each tributary following Jones et al. (2016).

$$T_s = \frac{\alpha - \mu}{1 + e^{\gamma(\beta - T_a)}} \tag{8}$$

This equation was also used to estimate temperatures for the data gaps of the tributaries in the original model, and was used to predict the future water temperatures of the tributaries for all of the alternatives in which the climate change conditions are assumed to exist.

Bowen Ratio Factor

In the original USGS meteorological input files a factor for Bowen Ratio term was erroneously dependent on wind speed rather than air temperature (Eq. 6). This minor error was corrected and had no impact on model results. The updated factor for Bowen ratio terms was used for all of the alternatives in this study.

Trinity River Accretion/Depletion Refinement

In the previous Trinity River study (Jones et al, 2016) daily mean flow rates for tributaries were estimated based on the recorded flow difference between the USGS stream gages "11525500 downstream of Lewiston Dam" and "11530000 at Hoopa, California", and assigned flows based on their drainage basin areas. When simulated Lewiston Dam releases were made for certain alternatives, flow conditions deviated notably from historic conditions. As a result of the original accretion/depletion and subsequent tributary flow assignment approach, negative flow rates for the tributaries were observed during several short periods in the late summer and the early fall when the flow through the reach is low and the flow coming from Lewiston Dam increases and decreases relatively rapidly. To eliminate the negative values, tributary flows were linearly interpolated between the values before and after those short periods during abrupt flow changes. In Figure 3-1, South Fork Trinity River estimated flow rates before and after the update, and the Lewiston Dam release during one of the periods mentioned above are shown.

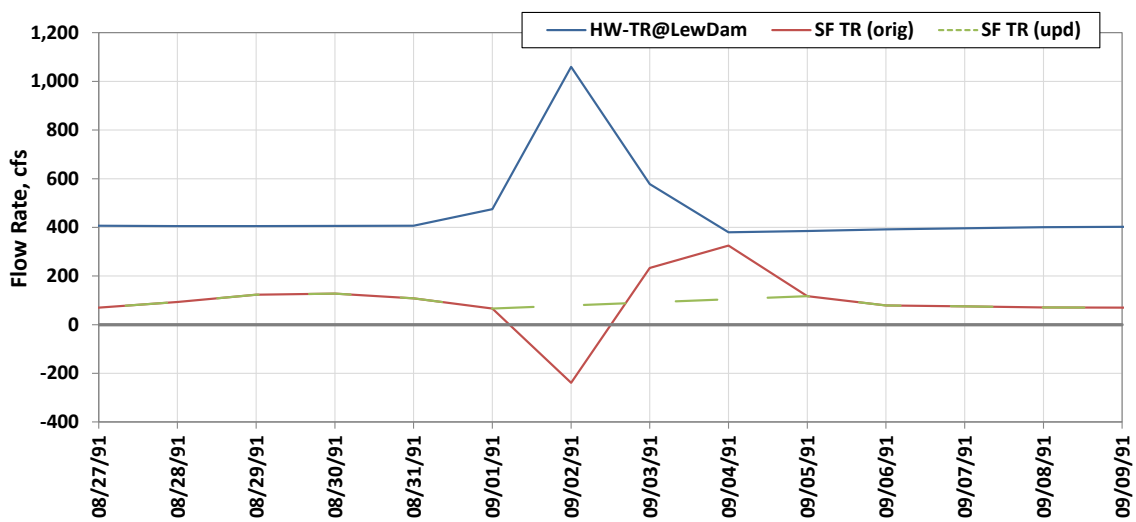


Figure 3-1. Daily mean Flow Rates of Headwater (HW) Boundary at Lewiston Dam, South Fork (SF) Trinity River (TR) Before and After the Update. 08/27/91 – 09/09/91

After the update on tributary flow estimations was completed, the total percentage change in the total volume of the tributaries in the model period was observed to be less than 0.05 percent.

Modeling Assumptions

After completing the model refinements listed above, the model was applied to the three alternatives with flow and temperatures provided from Trinity-Sacramento HEC-5Q Water Quality Model at Lewiston Dam forming the upstream boundary condition in the Trinity River. As noted previously, there were no changes to the upstream boundary condition in the Klamath River. Because the Klamath River RBM10 model starts at Upper Klamath Lake, over 200 miles upstream of the project area, minor changes of climate change in this boundary conditions are assumed negligible. That is, after traversing 200 plus miles of river under climate change meteorology with tributary inflow temperatures updated for climate change, the river was assumed to achieve an equilibrium and small changes in temperature at Upper Klamath Lake would have a minor impact on water temperature in the Klamath River at the confluence with the Trinity River. Any differences associated with this assumption would be identical with all three scenarios because no operational or flow modifications were made in the Klamath River modeling.

For temperatures in the Klamath River below the Trinity River a mass balance was used because there was not a representative model output node at this location. The mass balance:

$$T_{DS} = [(Q_{KR})(T_{KR})+(Q_{TR})(T_{TR})]/(Q_{KR}+Q_{TR})$$

where

T_{DS} = water temperature in the Klamath River below the confluence with the Trinity River

Q_{KR} = flow in the Klamath River upstream of the Trinity River

T_{KR} = water temperature in the Klamath River upstream of the Trinity River

Q_{TR} = flow in the Trinity River upstream of the Klamath River

T_{TR} = water temperature in the Trinity River upstream of the Klamath River

was used to calculate temperature in the Klamath River downstream of the Trinity River.

The RBM10 model simulates mean daily temperature values at locations along the river; the fishery analysis requires daily maximum and 7-day average daily maximum (7DADM) temperatures. These data values were simulated by determining the historical daily water temperature range from measurements along the Trinity River below Lewiston Dam and the Klamath River just above and below the Trinity River confluence. These historic ranges, coupled with the simulated RBM10 daily average water temperatures were used to estimate daily

maximum water temperature. The resulting daily maximum water temperatures were used to compute the 7DADM. Climate change was not considered when assessing historic daily water temperature ranges, i.e., future climate change was assumed to have minimal impact on the daily range of water temperatures in the project area.

Daily Range

The *historic daily range* is the difference between the *historical daily maximum* and the *historical daily minimum* temperature (Figure 3-2). The calculated *daily maximum* water temperature is based on simulated daily average temperature and the *historic daily range*.

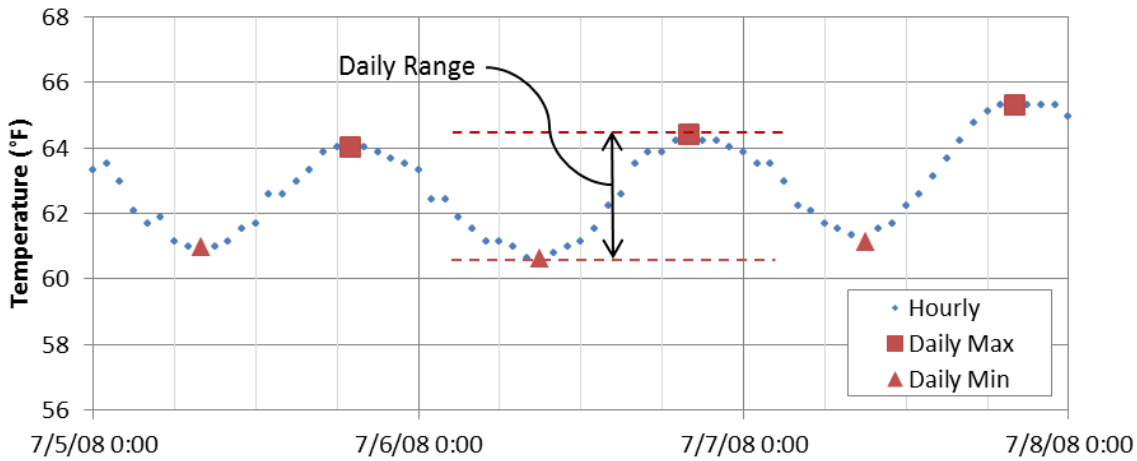
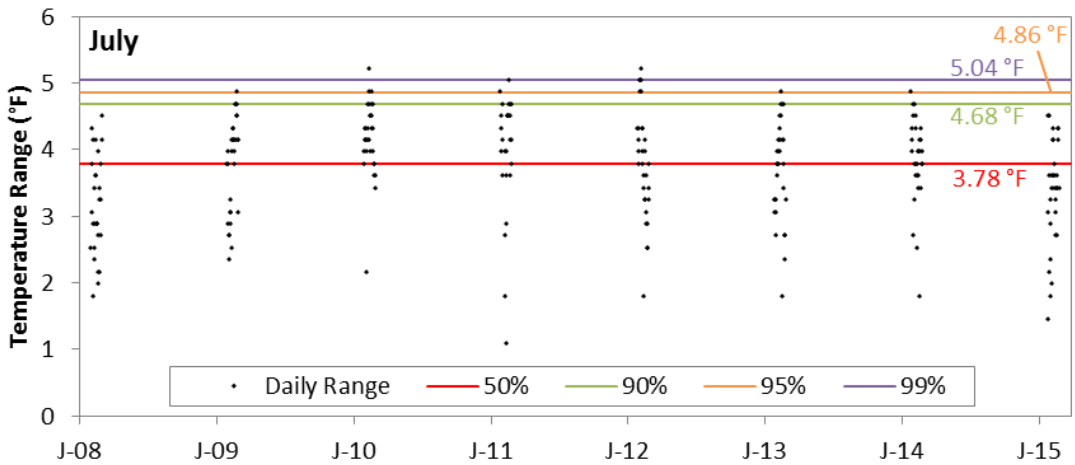


Figure 3-2. Illustration of How Historic Daily Temperature Range was Calculated

Non-Exceedance Probability After daily temperature ranges were calculated, monthly data were ranked for the 2008 to 2015 period and the 50th percentile, 90th percentile, 95th percentile and 99th percentile non-exceedance values were determined. Non-exceedance values define the likelihood that a daily temperature range, in a given month and at a particular location, would not exceed the identified value for the respective percentile values.

For example, in the figure below (Month: July; Location: Trinity River at Hoopa), the 50th percentile is 3.78°F, which means that 50 percent of the daily ranges in July at Hoopa are equal to or below 3.78°F (Figure 3-3). 90 percent, 95 percent, and 99 percent non-exceedance probabilities are also shown.



Note: Data taken from Trinity River at Hoopa, in July.

Figure 3-3. Daily Temperature Ranges Associated with 50 Percent, 90 Percent, 95 Percent and 99 Percent Non-exceedance Probabilities

Maximum Positive Deviation from Daily Average Temperatures After the daily ranges based on the associated non-exceedance probabilities were calculated, the *maximum positive deviation from daily average temperatures* was determined for each month. The maximum positive deviation from daily average temperature is half of the daily temperature range that is associated with the particular month and non-exceedance probability.

Table 3-1 is a sample of the table of the maximum positive deviation from the daily average. These values were calculated based on data for Trinity River at Hoopa. The higher the exceedance probability, the higher the 7DADM will be.

Table 3-1. Example Table of the Maximum Positive Deviation from a Daily Average

	Month											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Probability of Non Exceedance	(°F)	(°F)	(°F)	(°F)	(°F)	(°F)	(°F)	(°F)	(°F)	(°F)	(°F)	(°F)
0.50	0.5	0.7	0.9	1.3	1.6	1.9	1.9	1.6	1.3	1.1	0.7	0.5
0.90	0.9	1.1	1.5	2.1	2.3	2.4	2.3	2.2	1.7	1.4	1.1	0.9
0.95	1.0	1.2	1.6	2.2	2.4	2.5	2.4	2.3	1.8	1.4	1.2	1.0
0.99	1.1	1.4	1.8	2.4	2.6	2.7	2.5	2.9	2.0	1.7	1.4	1.4

Key:
ºF = degrees Fahrenheit

Daily Maximum Temperature
After the maximum positive deviations from the daily average were calculated, *daily maximum* temperatures of simulated RBM10 results (from 1980 to 2003) were calculated as follows:

Daily Maximum = Daily Average + Maximum Positive Deviation from Daily Average

The calculated daily maximum temperature is dependent upon the specified non-exceedance probability. For any given day, different daily maximum temperatures were calculated based on the different maximum positive deviations from the simulated daily average temperatures that were in turn dependent upon the selected non-exceedance probability (50, 90, 95, or 99th percentile) (Figure 3-4). These calculations were performed at all the study locations along the Trinity River and the Klamath River for the period between 1980 and 2003.

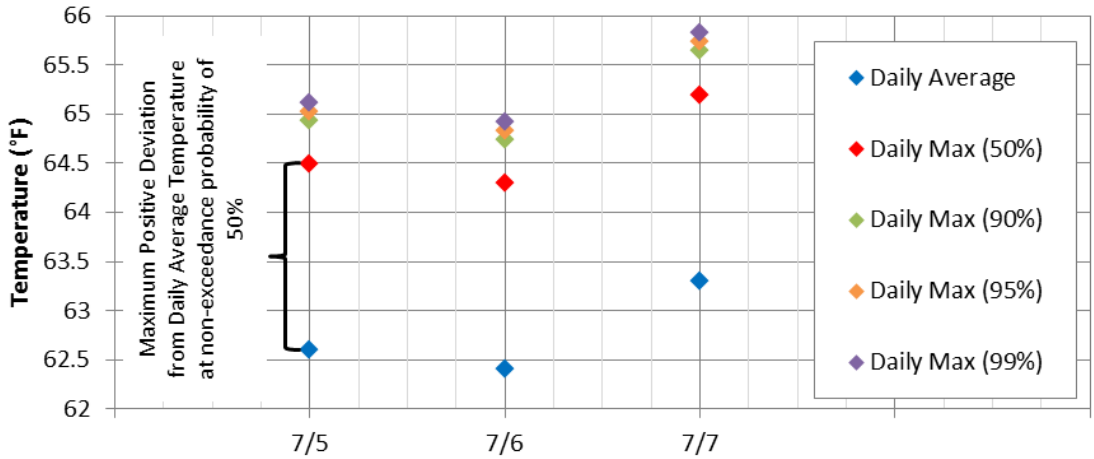


Figure 3-4. Example of Differing Values of Calculated Daily Maximum Temperature Based on the Specified Non-exceedance Probabilities

Seven-Day Average Daily Maximum (7DADM) Temperature

Seven-day running average temperature is the average of daily average temperatures from that day and the previous 6 days. The 7DADM is the running average of the daily maximum temperatures that have been calculated in the previous step (Figure 3-5). 7DADM were calculated for all years in the analysis for all months on the Trinity River. However, for the Klamath River 7DADM were only calculated for August and September.

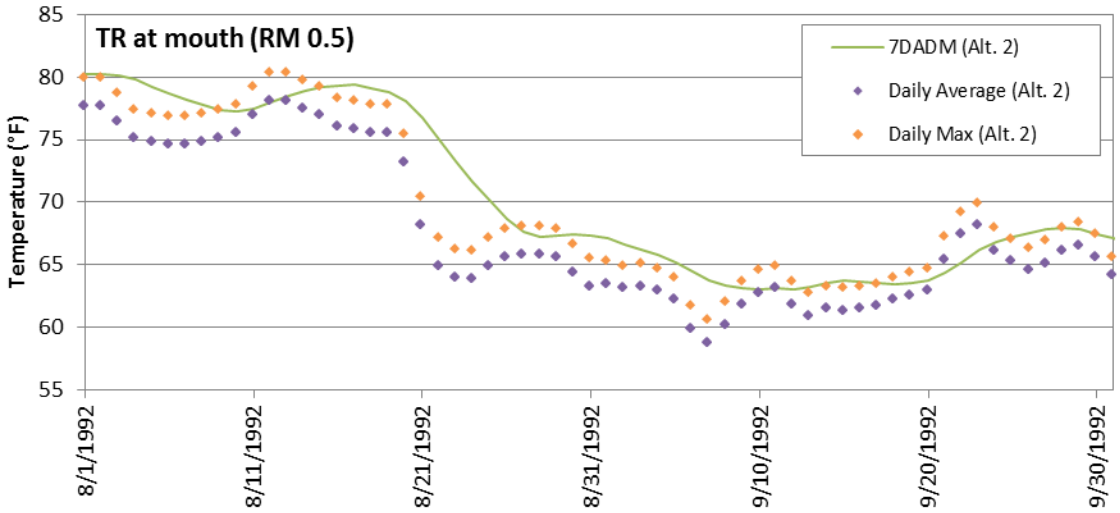


Figure 3-5. 7-Day Running Average of Daily Maximum Temperature (7DADM), Trinity River at Mouth

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Chapter 4
Fisheries Modeling

The analysis uses the Salmonid Population Model (SALMOD) to quantify fall-run, late fall-run, spring-run, and winter-run Chinook salmon survival and mortality for different life-stages within the Sacramento River, specifically from below Keswick Dam to the Red Bluff Pumping Plant (previously at Red Bluff Diversion Dam). The Interactive Object-Oriented Salmonid Simulation (IOS) model analysis is used to quantify winter-run Chinook salmon escapement and egg survival.

This section briefly describes the overall analytical approach and assumptions of both of these models.

Sacramento River SALMOD

The SALMOD model simulates the life-stage dynamics of fall-run, late fall-run, spring-run, and winter-run Chinook salmon populations within the Sacramento River, from below Keswick Dam to the Red Bluff Diversion Dam. The model uses daily flow and temperature data from the Sacramento River HEC5Q model to simulate the annual growth, movement, and mortality of the various riverine life stages of the four Chinook salmon runs based on an initial annual adult population that resets each biological year. The dynamics simulated are based on assumptions and relations specified in the model.

Application of SALMOD to Evaluate EIS Alternatives

The SALMOD model was used with output data from CalSim II and Trinity-Sacramento HEC-5Q Water Quality Model for each alternative to generate annual production (number of surviving members of each life stage) and annual mortality based on a variety of factors, including temperature and habitat (flow) based mortality. The Shasta Lake Water Resources Investigation Final EIS provides a detailed description of the SALMOD model structure, assumptions, and processes (Reclamation 2014).

Modeling Assumptions

For this analysis, the initial populations of adults were assumed to be 50,145 for fall-run, 9,306 for late fall-run, 489 for spring-run, and 5,710 for winter-run. These numbers are based on the geometric mean of 1999-2015 GrandTab spawning escapement data. In 1999, the Shasta Dam temperature control device was installed, resulting in a change in the population numbers. The assumed spawning distribution by reach is shown in Table 4-1. Assumptions of the spawning distributions were based on values used in the Shasta Lake Water Resource Investigation (Reclamation 2014).

Table 4-1. Upper Sacramento River Spawning Distributions

River Reach	Spawning Distribution (%) Fall-run	Spawning Distribution (%) Late Fall-run	Spawning Distribution (%) Spring-run	Spawning Distribution (%) Winter-run
Keswick Dam – Anderson Cottonwood Irrigation District (ACID) Dam	10.30	34.50	4.50	41.80
ACID Dam – Highway 44 Bridge	6.20	15.30	19.10	20.50
Highway 44 Bridge – Airport Road Bridge	11.10	22.80	31.70	35.40
Airport Road Bridge – Balls Ferry	19.2	18.30	17.60	1.90
Balls Ferry – Battle Creek	12.90	5.60	10.60	0.10
Battle Creek – Jellys Ferry	18.80	2.10	15.10	0.10
Jellys Ferry – Bend Bridge	13.60	1.00	1.50	0.20
Bend Bridge – Red Bluff Pumping Plant (previously Red Bluff Diversion Dam)	7.80	0.50	0.00	0.00

Key:
% = percent

Modeling Limitations

There are a number of acknowledged limitations and uncertainties inherent in SALMOD which limit the types of inferences that can be draw from the model. Like any model of a natural system, SALMOD is based on simplified rules and assumptions used to represent and approximate the complex factors that drive real-world conditions, which are of themselves often poorly or incompletely understood. While these assumptions can form a reasonably accurate and useful simulation of natural conditions, they cannot exactly replicate or predict actual conditions. These required simplifications and inherent uncertainties in model inputs naturally lead to uncertainties in the accuracy of model outputs for any individual model run relative to actual, real-world conditions.

Similarly, it should be noted that SALMOD is not a life cycle-population dynamics model, but rather a life stage model. SALMOD is intended to be used as an operations and alternatives screening tool, not a rigorous population dynamics model. By keeping the same starting population number, comparison against each alternative is able to be made. The identified limitations do not preclude the ability of SALMOD to identify potential effects to Chinook salmon caused by changes in operations. Some of the factors outside of the area of influence of the analysis for this EIS (for instance, ocean conditions) are poorly understood and are themselves subject of both environmental and anthropogenic forces, making them highly uncertain and thus difficult to quantify or even fully anticipate. Inclusion of those factors outside of the areas and life stages influenced by this project could obscure the modeling effort and as such, the influence of the project, by introducing significant uncertainty from factors (and life stages) that are not directly influenced by the project. Therefore, the model has been formulated to isolate the effect of the project on anadromous fish survival by excluding factors outside of the area of influence of this project.

In light of these uncertainties, SALMOD is not used as a predictive tool for explicit population estimation; rather it is used as a comparative tool to evaluate relative change between alternatives. If the modeling assumptions and parameters form a reasonably accurate

representation of the relationship between input variables and outputs, and the nature of those relationships will not change between scenarios, the model is valid for comparing between alternatives despite its inherent uncertainty (identical assumptions will influence all scenarios and lead to similar uncertainties/inaccuracies that cancel out in the process of comparison). A valid use of the model results is to identify general trends (such as positive or negative responses) and the relative magnitude of impacts (such as percent changes). Simulated fish production values should be viewed as an index of production for each alternative, and should not be treated as an explicit prediction of absolute numbers of fish production under any alternative.

Interactive Object-Oriented Salmon Simulation Model for Winter-Run Chinook Salmon

The IOS model for winter-run Chinook Salmon simulates the entire life cycle of winter-run Chinook Salmon through successive generations. This approach allows for the evaluation of individual life-stage effects on the long-term trajectory of the population. A detailed description of the model and sensitivity analysis can be found in Zeug et al. (2012).

The IOS model is composed of six model stages that are arranged sequentially to account for the entire life cycle of the winter-run, from eggs to returning spawners. In sequential order, the IOS model stages are: (1) spawning, which models the number and temporal distribution of eggs deposited in the gravel at the spawning grounds; (2) early development, which models the impact of temperature on maturation timing and mortality of eggs at the spawning grounds; (3) fry rearing, which models the relationship between temperature and mortality of salmon fry during the river-rearing period; (4) river migration, which estimates the mortality of migrating salmon smolts in the Sacramento River between the spawning and rearing grounds and the Delta; (5) Delta passage, which models the impact of flow, route selection, and water exports on the survival of salmon smolts migrating through the Delta to San Francisco Bay; and (6) ocean survival, which estimates the impact of natural mortality and ocean harvest to predict survival and spawning returns (escapement) by age. Below is a detailed description of each model stage.

The IOS model uses a system dynamics modeling framework, a technique that is used for framing and understanding the behavior of complex systems over time. System dynamics models are made up of stocks (e.g., number of fish) and flows (e.g., sources of mortality) that are informed by mathematical equations. IOS was implemented in the software GoldSim, which enables the simulation of complex processes through creation of simple object relationships, while incorporating Monte Carlo stochastic methods.

Application of IOS to Evaluate EIS Alternatives

The Delta portion of the model is composed of eight reaches and four junctions (see Table 4-2) selected to represent primary salmonid migration corridors where high quality fish and hydrodynamic data were available. For simplification, Sutter Slough and Steamboat Slough are combined as the reach “SS,” and the forks of the Mokelumne River and Georgiana Slough are combined as “Geo/DCC.” The Geo/DCC reach can be entered by the Mokelumne River fall-run at the head of the South and North forks of the Mokelumne River or by Sacramento runs through the combined junction of Georgiana Slough and Delta Cross Channel (Junction C). The Interior

Delta reach can be entered from three different pathways: (1) Geo/DCC, (2) San Joaquin River via Old River Junction (Junction D), or (3) Old River via Junction D. Due to lack of data informing specific routes through the Interior Delta, or tributary-specific survival, the entire Interior Delta region is treated as a single model reach. The four distributary junctions depicted in the Delta portion of the model are: (1) Sacramento River at Freemont Weir (head of Yolo Bypass), (2) Sacramento River at head of Sutter and Steamboat Sloughs, (3) Sacramento River at the combined junction with Georgiana Slough and Delta Cross Channel, and (4) San Joaquin River at the head of Old River. Due to lack of data informing specific routes through the Interior Delta, or tributary-specific survival, the entire Interior Delta region is treated as a single model reach.

For Delta reaches where acoustic tagging data supported migration speed responses to flow (Sac1, Sac2, Geo/DCC), daily migration speed is influenced by mean daily flow. Migration speed is modeled as a logarithmic function of reach-specific flow occurring on the first day smolts entered a particular reach.

Table 4-2. Descriptions of Modeled Delta Reaches and Junctions in the IOS Model

Reach/ Junction	Description	Reach Length (kilometers)
Sac1	Sacramento River from Freeport to junction with Sutter Slough	41.04
Sac2	Sacramento River from Sutter Slough junction to junction with DCC	10.78
Sac3	Sacramento River from DCC to Rio Vista	22.37
Sac4	Sacramento River from Rio Vista to Chipps Island	23.98
Yolo	Yolo Bypass from entrance at Fremont Weir to Rio Vista	- [a]
SS	Combined reach of Sutter Slough and Steamboat Slough ending at Rio Vista	26.72
Geo/DCC	Combined reach of Georgiana Slough, DCC, and Sough and North forks of the Mokelumne River ending at confluence with San Joaquin River	25.59
Interior Delta	Begins at end of reach Geo/DCC, San Joaquin River via Junction D, or Old River via Junction D, and ends at Chipps Island	- [b]
A	Junction of Yolo Bypass and Sacramento River	Not applicable
B	Combined junction of Sutter Slough and Steamboat Slough with Sacramento River	Not applicable
C	Combined junction of DCC and Georgiana Slough with Sacramento River	Not applicable
D	Junction of Old River with San Joaquin River	Not applicable

Notes:
[a] Reach length for Yolo Bypass is currently undefined because reach length is not currently used to calculate Yolo Bypass speed and ultimate travel time.
[b] Reach length for the Interior Delta is undefined due to multiple pathways salmon can take. Timing through the Interior Delta does not affect Delta survival because there are no Delta reaches located downstream of the Interior Delta.
Key:
DCC = Delta Cross Channel

Reach-specific survival through a given Delta reach is calculated and applied the first day smolts enter the reach. For reaches where literature or available tagging data showed support for reach-level responses to environmental variables, survival is influenced by flow (Sac1, Sac2, Sac3, Sac4, SS, Interior Delta via San Joaquin River, and Interior Delta via Old River) or water exports (Interior Delta via Geo/DCC). For these reaches, daily flow (DSM2 data) or exports (CalSim II data) occurring the day of reach-entry is used to predict reach survival through the entire reach. For all other reaches (Geo/DCC and Yolo), reach survival is uninfluenced by Delta conditions and is informed by means and standard deviations of survival from acoustic tagging studies.

At each Delta junction in the model, smolts move in relation to the proportional movement of flow entering each route. Daily DSM2 flow data entering each route are used to inform the proportion of smolts entering each route at a junction. Smolts move in direct proportion to flow at all junctions except Junction C, where a non-proportional relationship is applied as defined by acoustic tagging study data.

Daily simulated water temperature data at Bend Bridge from the Sacramento River Basin Water Temperature Model were applied to inform temperature-dependent egg and fry survival. Daily mortality of eggs and fry is exponentially related to daily water temperature at Bend Bridge.

A major assumption of the IOS model is that surrogate fish data can be used to inform many model relationships. When local data are limited, model relationships can often be informed by field data from outside the study region, laboratory studies in controlled experimental settings, or artificially raised (hatchery) surrogates. For example, many model relationships rely on data from tagged hatchery surrogates because experimental studies often rely on easily accessible hatchery-origin fish and assume that fish responses are at least similar among individuals of different natal origins. In addition to limited data on wild fish, many of the model relationships are informed by data from a single Chinook Salmon race, thereby making the assumption that all races move, grow, and survive according to the same rules.

Modeling Assumptions

The IOS model uses scenario-specific daily DSM2, CalSim II, and Sacramento River Basin Water Temperature Model (Trinity-Sacramento HEC-5Q Water Quality Model) data as model input for each alternative as described above. Daily DSM2 data inform fish migration speed, reach-specific survival, and routing at Delta junctions. Daily export data from CalSim II are used to inform export-dependent survival of salmon smolts that enter the Interior Delta from the Geo/DCC reach. Sacramento River Basin Water Temperature Model data at Bend Bridge, California are used to inform temperature-dependent egg and fry survival in the egg development and fry rearing stages of the model.

References

Reclamation (U.S. Department of the Interior, Bureau of Reclamation). 2014. Shasta Lake Water Resources Investigation Final Environmental Impact Statement. December.

Zeug et al. (Zeug, S.C., P.S. Bergman, B.J. Cavallo and K.S. Jones). 2012. “Application of a life cycle simulation model to evaluate impacts of water management and conservation actions on an endangered population of Chinook Salmon.” *Environmental Modeling and Assessment* 17:455-467.

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Chapter 5
Hydropower Modeling

This section summarizes the power modeling methodology used for the No Action Alternative and action alternatives. Two spreadsheet tools were used to estimate average annual peaking power capacity, energy generation, and energy use at CVP and SWP facilities:

- LTGen (CVP_Power_Future): analyzes CVP facilities
- SWP_Power (SWP_Power_Future): analyzes SWP facilities

The LTGen tool includes 14 pumping and 11 generation CVP facilities. The SWP Power tool includes 13 pumping and 8 SWP generation facilities. Energy generation/use at the CVP and SWP facilities are determined using facility specific physical information and empirical energy factors provided by the Western Area Power Authority (Western) for CVP facilities and by the DWR Operations Control Office (OCO) for SWP facilities, with CalSim II mean monthly project operation data. The resulting monthly energy generation is split into on and off peak usage based on historical operation policies of the project intending to minimize energy costs. Transmission losses are estimated to estimate energy use and generation at load center, as a percentage of energy use or generation.

Capacity and ancillary services are not directly estimated by the tools. These parameters required a much shorter time step than the mean monthly timestep.

Application of LTGen and SWP_Power to Evaluate EIS Alternatives

The models used the appropriate monthly operations data from the CalSim II output for each alternative for the entire 1922 to 2003 simulation period.

Modeling Assumptions

These models assume that the action alternatives will not would have an effect on the physical features of any of the CVP or SWP facilities nor operative outside of their typical operating range.

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Chapter 6
Delta Hydrodynamics and Salinity Modeling

DSM2 is a one-dimensional hydrodynamic and water quality model used to simulate hydrodynamics, water quality, and particle tracking in the Delta. DSM2 represents the best available planning model for Delta tidal hydraulic and salinity modeling. It is appropriate for describing the existing conditions in the Delta, as well as performing simulations for the assessment of incremental environmental effects caused by future facilities and operations.

The DSM2 model has three separate components or modules: HYDRO, QUAL, and PTM.

HYDRO simulates velocities and water surface elevations and provides the flow input for QUAL and PTM. DSM2-HYDRO outputs are used to predict changes in flow rates and depths, and their effects on covered species, as a result of the EIS and climate change.

The QUAL module simulates fate and transport of conservative and non-conservative water quality constituents, including salts, given a flow field simulated by HYDRO. Outputs are used to estimate changes in salinity, and their effects on covered species, as a result of project implementation and climate change. The QUAL module is also used to simulate source water fingerprinting, which allows determining the relative contributions of water sources to the volume at any specified location. Reclamation's 2008 *Coordinated Long-Term Operation of the Central Valley Project and State Water Project (LTO) Biological Assessment* (BA) Appendix F provides more information about DSM2 (Reclamation 2008).

DSM2-PTM simulates pseudo 3-D transport of neutrally buoyant particles based on the flow field simulated by HYDRO. This module was not used in this EIS analysis.

Additional information on DSM2 can be found on the DWR Modeling Support Branch website at http://baydeltaoffice.water.ca.gov/modeling/.

Application of DSM2 to Evaluate EIS Alternatives

DSM2 v8.0.6 was used in modeling of all alternatives in this EIS using a period of simulation consistent with the CalSim II model - water years 1922 to 2003. The model was modified to include the 2030 level of climate change by incorporating the 15-cm sea level rise consistent with the 2030 level climate change assumption. This is also consistent with the delta salinity ANN used in the CalSim II model for inclusion of in-delta response to operational and stream flow changes of the alternatives.

As used in this EIS, DSM2 HYDRO provides tidal flow, stage and velocity outputs at all locations in the model on a 15-minute time step. DSM2 QUAL provides salinity (electrical conductivity (EC)) on a 15-minute time step.

The agricultural diversions, return flows, and corresponding salinities used in DSM2 are on a monthly time step. The implementation of DCC gate operations in DSM2 assumes that the gates are open from the beginning of a month, irrespective of the water quality needs in the south Delta.

The input assumptions stated earlier should be considered when DSM2 EC results are used to evaluate performance of a baseline or an alternative against the standards. Even though CalSim II releases sufficient flow to meet the standards on a monthly average basis, the resulting EC from DSM2 may be over the standard for part of a month and under the standard for part of the month, depending on the spring/neap tide and other factors (for example, simplification of operations). It is recommended that the results are presented on a monthly basis. Frequency of compliance with a criterion should be computed based on monthly average results. Averaging on a sub-monthly (14-day or more) scale may be appropriate as long as the limitations with respect to the compliance of the baseline model are described in detail and the alternative results are presented as an incremental change from a baseline model.

Modeling Assumptions

The DSM2 model was used with CalSim II outputs of boundary inflow, export, and outflow conditions for each alternative. No other inputs or assumptions were changed.

References

Reclamation (U.S. Department of the Interior, Bureau of Reclamation). 2008. *Biological Assessment on the Continued Long-term Operations of the Central Valley Project and the State Water Project.* Appendix F Sacramento-San Joaquin Delta Hydrodynamic and Water Quality Model (DSM2 Model). August.

Chapter 7
Economics Modeling

The Statewide Agricultural Production Model (SWAP) and the IMpact Analysis for PLANning Model (IMPLAN) were selected for analysis of the potential change to agricultural and municipal economics respectively, which could result from changes in water supply.

This section describes the overall analytical approach and assumptions for use of these models in the analysis.

Statewide Agricultural Production Model

The SWAP model is a regional agricultural production and economic optimization model that simulates the decisions of farmers across 93 percent of agricultural land in California. It is an improvement and extension of the Central Valley Production Model (CVPM). The CVPM was developed in the early 1990s and was used to assess the impacts of the Central Valley Project Improvement Act (Reclamation and USFWS 1999). The SWAP model allows for greater flexibility in production technology and input substitution than CVPM does, and has been extended to allow for a range of analyses, including interregional water transfers and climate change effects. Its first application was to estimate the economic scarcity costs of water for agriculture in the statewide hydro-economic optimization model for water management in California, CALVIN (Draper et al. 2003). More recently, the SWAP model has been used to estimate the economic losses caused by salinity in the Central Valley (Howitt et al. 2009a), economic losses to agriculture in the Sacramento-San Joaquin Delta (Lund et al. 2007), and economic effects of water shortage to Central Valley agriculture (Howitt et al. 2009b). The model was updated and augmented for use by Reclamation in 2012 (Reclamation 2012). It is also being used in several ongoing studies of water projects and operations. The SWAP model has been subject to peer review and technical details can be found in “Calibrating Disaggregate Economic Models of Irrigated Production and Water Management” (Howitt et al. 2012).

The SWAP model has 27 base regions in the Central Valley. The model is also able to include agricultural areas of the Central Coast, the Colorado River region that includes Coachella, Palo Verde and the Imperial Valley, and San Diego, Santa Ana, and Ventura and the South Coast; however, data for those regions have not been updated recently. Figure 7-1 shows the numbered California agricultural areas covered in SWAP. Table 7-1 details the major water users in each of the regions.

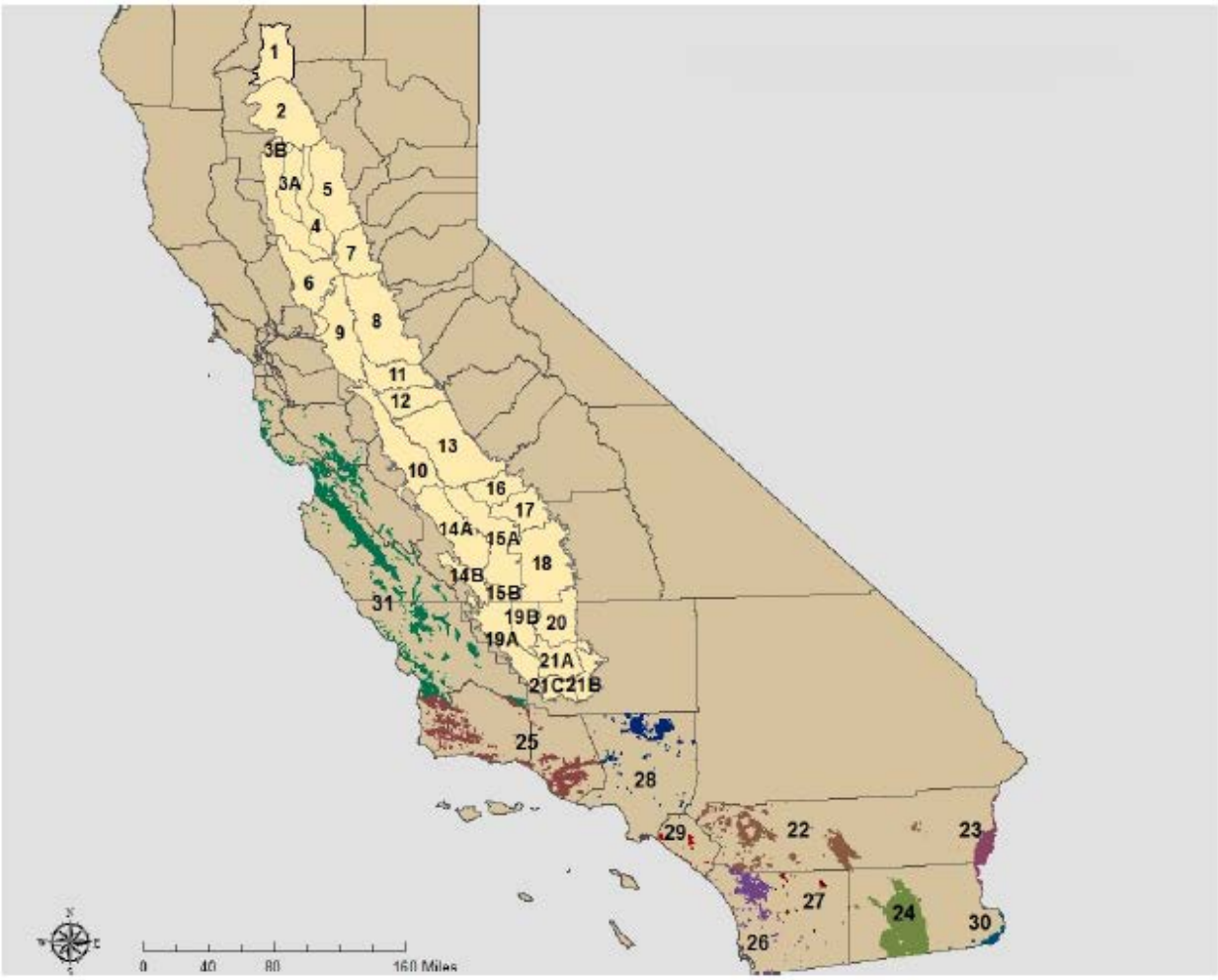

Figure 7-1. SWAP Model Coverage of Agriculture in California

Table 7-1. SWAP Model Region Summary

SWAP Region	Major Surface Water Users
1	CVP Users: Anderson Cottonwood I.D., Clear Creek C.S.D., Bella Vista W.D., and other Sacramento River Water Rights Settlement Contractors.
2	CVP Users: Corning Canal, Kirkwood W.D., Tehama, and other Sacramento River Water Rights Settlement Contractors.
3a	CVP Users: Glenn Colusa I.D., Provident I.D., Princeton-Codora I.D., Maxwell I.D., and Colusa Basin Drain M.W.C.
3b	Tehama Colusa Canal Service Area. CVP Users: Orland-Artois W.D., most of Colusa County, Davis W.D., Dunnigan W.D., Glide W.D., Kanawha W.D., La Grande W.D., and Westside W.D.
4	CVP Users: Princeton-Codora-Glenn I.D., Colusa I.C., Meridian Farm W.C., Pelger Mutual W.C., Reclamation District 1004, Reclamation District 108, Roberts Ditch I.C., Sartain M.D., Sutter M.W.C., Swinford Tract I.C., Tisdale Irrigation and Drainage Company, and other Sacramento River Water Rights Settlement Contractors.
5	Most Feather River Region riparian and appropriative users.
6	Yolo and Solano Counties. CVP Users: Conaway Ranch and other Sacramento River Water Rights Settlement Contractors.
7	Sacramento County north of American River. CVP Users: Natomas Central M.W.C., other Sacramento River Water Rights Settlement Contractors, Pleasant Grove-Verona W.M.C., and Placer County Water Agency.
8	Sacramento County south of American River and northern San Joaquin County.
9	Direct diverters within the Delta region. CVP Users: Banta Carbona I.D., West Side W.D., and Plainview W.D.
10	Delta Mendota service area. CVP Users: Panoche W.D., Pacheco W.D., Del Puerto W.D., Hospital W.D., Sunflower W.D., West Stanislaus W.D., Mustang W.D., Orestimba W.D., Patterson W.D., Foothill W.D., San Luis W.D., Broadview W.D., Eagle Field W.D., Mercy Springs W.D., San Joaquin River Exchange Contractors.
11	Stanislaus River water rights: Modesto I.D., Oakdale I.D., and South San Joaquin I.D.
12	Turlock I.D.
13	Merced I.D. CVP Users: Madera I.D., Chowchilla W.D., and Gravelly Ford W.D.
14a	CVP Users: Westlands W.D.
14b	Southwest corner of Kings County.
15a	Tulare Lake Bed. CVP Users: Fresno Slough W.D., James I.D., Tranquillity I.D., Traction Ranch, Laguna W.D., and Reclamation District 1606.
15b	Dudley Ridge W.D. and Devil's Den W.D. (Castaic Lake).
16	Eastern Fresno County. CVP Users: Friant-Kern Canal Water Authority, Fresno I.D., Garfield W.D., and International W.D.
17	CVP Users: Friant-Kern Canal, Hills Valley I.D., Tri-Valley W.D., and Orange Cove I.D.
18	CVP Users: Friant-Kern Canal, County of Fresno, Lower Tule River I.D., Pixley I.D., portion of Rag Gulch W.D., Ducor I.D., County of Tulare, most of Delano-Earlimart I.D., Exeter I.D., Ivanhoe I.D., Lewis Creek W.D., Lindmore I.D., Lindsay-Strathmore I.D., Porterville I.D., Sausalito I.D., Stone Corral I.D., Tea Pot Dome W.D., Terra Bella I.D., and Tulare I.D.
19a	SWP Service Area, including Belridge W.S.D., Berrenda Mesa W.D.
19b	SWP Service Area, including Semitropic W.S.D.
20	CVP Users: Friant-Kern Canal Water Authority, Shafter-Wasco I.D.
21a	CVP Users: Cross Valley Canal water users and Friant-Kern Canal Water Authority.
21b	Arvin Edison W.D.
21c	SWP service area: Wheeler Ridge-Maricopa W.S.D.
23-30	Central Coast, Desert, and Southern California.

Notes:

The list above does not include all water users. It is intended only to indicate the major users or categories of users. All regions in the Central Valley also include private groundwater pumpers.

Key:
C.S.D. = Community Service District
I.C. = Irrigation Company
I.D. = Irrigation District
M.W.C. = Mutual Water Company
W.D. = Water District
W.S.D. = Water Storage District

Application of SWAP to Evaluate EIS Alternatives

EIS modeling objectives accomplished with the SWAP model included the evaluation of the following potential impacts:

- Effects on irrigated agricultural acreage
- Effects on total production value

Modeling Assumptions

This section is a non-technical overview of the underlying assumptions and inputs of the SWAP model. It is important to note that SWAP, like any model, is a representation of a complex system and requires assumptions and simplifications to be made. All analyses using SWAP should be explicit about the assumptions and provide sensitivity analysis where appropriate. More detailed assumptions regarding calibration using mathematical programming, crop demand functions, water supply and groundwater pumping, and more see Reclamation 2012.

The SWAP model assumes that growers select the crops, water supplies, and other inputs to maximize profit subject to resource constraints, technical production relationships, and market conditions. Growers face competitive markets, where no one grower can influence crop prices. The competitive market is simulated by maximizing the sum of consumer and producer surplus subject to the following characteristics of production, market conditions, and available resources:

- Constant Elasticity of Substitution (CES) production functions for every crop in every region. CES has four inputs: land, labor, water, and other supplies. CES production functions allow for limited substitution between inputs, which allows the model to estimate both total input use and input use intensity. Parameters are calculated using a combination of prior information and the method of Positive Mathematical Programming (PMP) (Howitt 1995a, Howitt 1995b).
- Marginal land cost functions are estimated using PMP. Additional land brought into production is assumed to be of lower value and thus requires a higher cost to cultivate. The PMP functions capture this cost by using acreage response elasticities, which relate change in acreage to changes in expected returns and other information.
- Groundwater pumping cost including depth to groundwater.
- Crop demand functions.
- Resource constraints on land, labor, water, and, if applicable, other input availability by region.
- Other agronomic and economic constraints. For example, a minimum regional silage production to meet dairy herd feeding requirements can be imposed if appropriate.

The model chooses the optimal amounts of land, water, labor, and other input use subject to these constraints and definitions. Profit is revenue minus costs, where revenue is price multiplied by yield per acre then multiplied by total acres. Trade-offs among production inputs are

described by the CES production functions. Costs are observable input costs plus the PMP cost function, which represents changes in marginal productivity of land. Downward-sloping crop demand curves guarantee that with all else constant, as production increases, crop price decreases (and vice-versa). Over time, crop demands may shift, driven by real income growth and population increases. External data and elasticities are used to estimate the magnitude of these shifts.

The SWAP model incorporates CVP and SWP agricultural water supplies, other local surface water supplies, and groundwater. As conditions change within a SWAP region (e.g., the quantity of available project water supply increases or the cost of groundwater pumping increases), the model optimizes production by adjusting the crop mix, water sources and quantities used, and other inputs. Land will be fallowed when that is the most cost-effective response to resource conditions.

The SWAP model is used to compare the long-run response of agriculture to potential changes in CVP and SWP agricultural water delivery, other surface or groundwater conditions, or other economic values or restrictions. Results from the CalSim II model are used as inputs into SWAP through a standardized data linkage tool.

The model self-calibrates using PMP, which has been used in models since the 1980s (Vaux and Howitt 1984) and was formalized in 1995 (Howitt 1995a). PMP allows the modeler to infer the marginal cost and return conditions affecting decisions of farmers while only being able to observe limited average production cost and return data. PMP captures this information through a nonlinear cost or revenue function introduced to the model.

SWAP Model Coverage

Crops are aggregated into 20 crop groups, which are the same across all regions. Each crop group may represent a number of individual crops, but many are dominated by a single crop. Irrigated acres represent acreage of all crops within the group, while production costs and returns are represented by a single proxy crop for each group. The current 20 crop groups were defined in collaboration with Reclamation and DWR and updated in March 2011. For each group, the representative (proxy) crop is chosen based on four criteria:

- A detailed production budget is available from the University of California Cooperative Extension (UCCE).
- It is the largest or one of the largest acreages within a group.
- Its water use (applied water) is representative of water use of the crops in the group.
- Its gross and net returns per acre are representative of the crops in the group.

The relative importance of these criteria varies by crop. Crop group definitions and the corresponding proxy crop are shown in Table 7-2.

Table 7-2. Statewide Agricultural Production Model Crop Groups

SWAP Definition	Proxy Crop	Other Crops
Almonds and Pistachios	Almonds	Pistachios
Alfalfa	Alfalfa hay	–
Corn	Grain corn	Corn silage
Cotton	Pima cotton	Upland cotton
Cucurbits	Summer squash	Melons, cucumbers, pumpkins
Dry Beans	Dry beans	Lima beans
Fresh Tomatoes	Fresh tomatoes	–
Grain	Wheat	Oats, sorghum, barley
Onions and Garlic	Dry onions	Fresh onions, garlic
Other Deciduous	Walnuts	Peaches, plums, apples
Other Field	Sudan grass hay	Other silage
Other Truck	Broccoli	Carrots, peppers, lettuce, other vegetables
Pasture	Irrigated pasture	–
Potatoes	White potatoes	–
Processing Tomatoes	Processing tomatoes	–
Rice	Rice	–
Safflower	Safflower	–
Sugar Beet	Sugar beets	–
Subtropical	Oranges	Lemons, misc. citrus, olives
Vine	Wine grapes	Table grapes, raisins

SWAP Model Inputs and Supporting Data Land use data in the SWAP model correspond to the year 2010 and were prepared by DWR analysts and the current version of the SWAP model calibrates to 2010 as a relatively normal base year. All prices and costs in SWAP are in constant 2010 dollars for consistency with the land use data. Table 7-3 summarizes input data and sources used in the SWAP model.

Table 7-3. SWAP Model Input Data Summary

Input	Source	Notes
Land Use	DWR	Base year 2010.
Crop Prices	County agricultural commissioners	By proxy crop using 2010-2012 average prices, indexed to 2010 price level.
Crop Yields	UCCE crop budgets	By proxy crop for various years (most recent available).
Interest Rates	UCCE crop budgets	Crop budget interest costs adjusted to year 2010.
Land Costs	UCCE crop budgets	By proxy crop for various years (most recent available). In 2010 dollars.
Other Supply Costs	UCCE crop budgets	By proxy crop for various years (most recent available). In 2010 dollars.
Labor Costs	UCCE crop budgets	By proxy crop for various years (most recent available). In 2010 dollars.
Surface Water Costs	Reclamation, DWR, individual districts	By SWAP model region. In 2010 dollars.
Groundwater Costs	PG&E, individual districts	Total cost per acre-foot includes fixed, O&M, and energy cost. In 2010 dollars.
Irrigation Water	DWR	Average crop irrigation water requirements in acre-feet per acre.
Available Water	CVPM, DWR, Reclamation, individual districts	By SWAP model region and water supply source.
Elasticities	Russo et al. 2008	California estimates.

Key:
CVPM = Central Valley Production Model
DWR = California Department of Water Resources
O&M = operations and maintenance
PG&E = Pacific Gas & Electric Company
SWAP = Statewide Agricultural Production Model
UCCE = University of California Cooperative Extension

2030 Assumptions Analysis of alternatives assumed 2030 conditions. Projected CVP and SWP water deliveries were provided by CalSim II results as described in Chapter 2, "Water Operations Modeling." The SWAP model includes future crop demand functions based on shifts over time due to growth in population and changes in real income per capita forecasted to 2030 conditions.

Model Limitations and Applicability The SWAP model is an optimization model that makes the best (most profitable) adjustments to water supply and other changes. Constraints can be imposed to simulate restrictions on how much adjustment is possible or how fast the adjustment can realistically occur. Nevertheless, an optimization model can tend to over-adjust and minimize costs associated with detrimental changes or, similarly, maximize benefits associated with positive changes.

SWAP does not explicitly account for the dynamic nature of agricultural production; it provides a point in time comparison between two conditions. This is consistent with the way most economic and environmental impact analysis is conducted, but it can obscure sometimes important adjustment costs.

SWAP also does not explicitly incorporate risk or risk preferences (e.g., risk aversion) into its objective function. Risk and variability are handled in two ways. First, the calibration procedure for SWAP is designed to reproduce observed crop mix, so to the extent that crop mix

incorporates farmers' risk spreading and risk aversion, the starting, calibrated SWAP base condition will also. Second, variability in water delivery, prices, yields, or other parameters can be evaluated by running the model over a sequence of conditions or over a set of conditions that characterize a distribution, such as a set of water year types.

Groundwater is an alternative source to augment local surface, SWP, and CVP water delivery in all SWAP regions. The cost and availability of groundwater therefore has an important effect on how SWAP responds to changes in delivery. However, SWAP is not a groundwater model and does not include any direct way to adjust pumping lifts and unit pumping cost in response to long-run changes in pumping quantities. Economic analysis using SWAP must rely on an accompanying groundwater analysis.

Impact Analysis for Planning Model

The IMPLAN model is the most widely used input-output (I-O) impact model system in the United States. Much more than a set of multipliers, it provides users with the ability to define industries, economic relationships and projects to be analyzed. It can be customized for any county, region, or state, and used to assess the "ripple effects" or "multiplier effects" caused by increasing or decreasing spending in various parts of the economy. This is used primarily to assess the economic impacts of facilities or industries, or changes in their level of activity in a given area.

IMPLAN is a static model that estimates impacts for a snapshot in time when the impacts are expected to occur, based on the makeup of the economy at the time of the underlying IMPLAN data. IMPLAN measures the initial impact to the economy but does not consider long-term adjustments as labor and capital move into alternative uses. This approach is used to compare the alternatives. Realistically, the structure of the economy will adapt and change; therefore, the IMPLAN results can only be used to compare relative changes between alternatives and the No Action Alternative and cannot be used to predict or forecast future employment, labor income, or output (sales).

I-O models measure commodity flows from producers to intermediate and final consumers. Purchases for final use (final demand) drive the model. Industries produce goods and services for final demand and purchase goods and services from other producers. These other producers, in turn, purchase goods and services. This buying of goods and services (indirect purchases) continues until leakages from the analysis area (imports and value added) stop the cycle. These indirect and induced effects (the effects of household spending) can be mathematically derived using a set of multipliers. The multipliers describe the change in output for each regional industry caused by a 1-dollar change in final demand. Figure 7-2 illustrates the concept of I-O modeling.

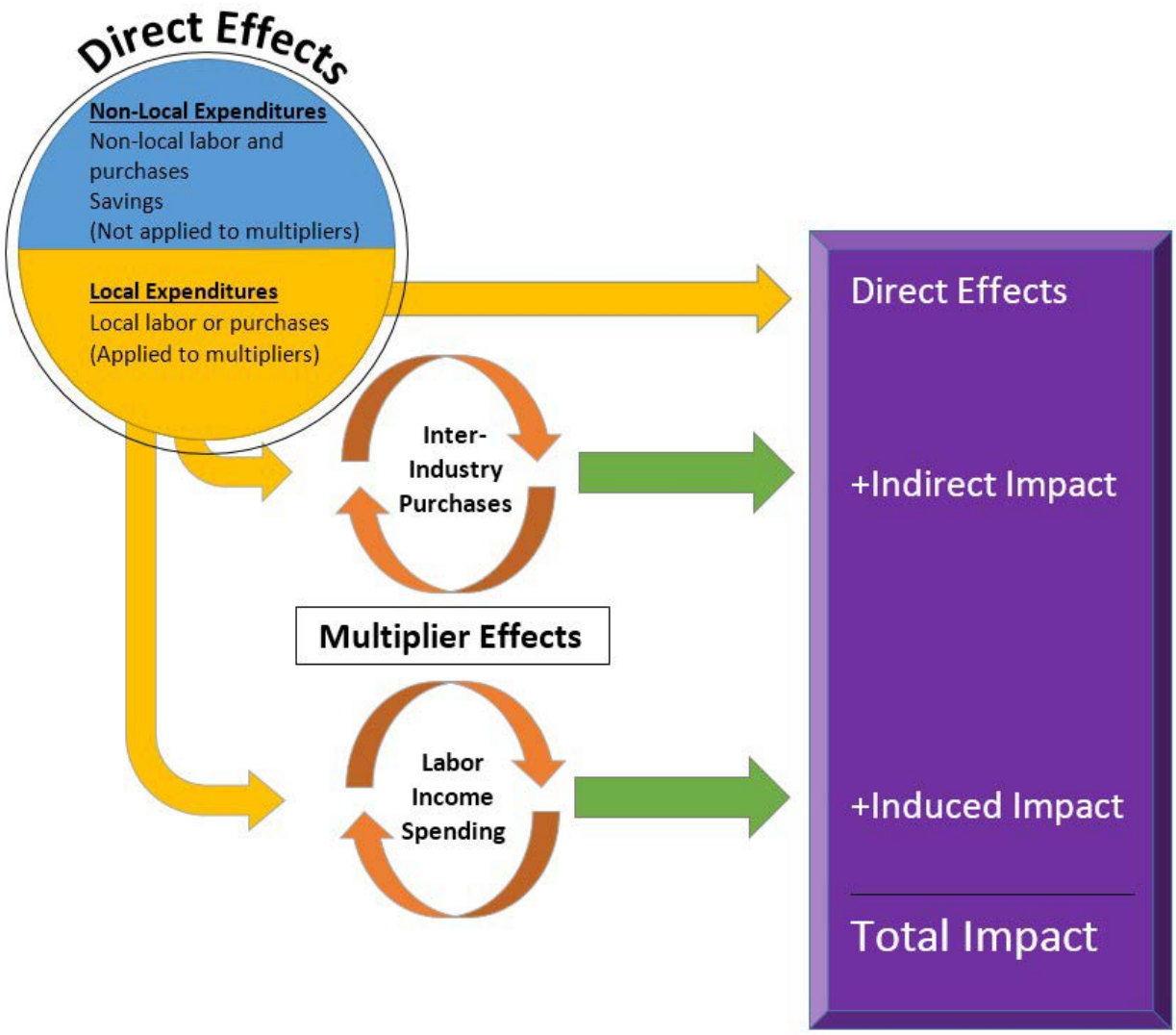

Figure 7-2. Input-Output Modeling Concept

IMPLAN includes estimates of final demands and final payments for each county developed from government data, a national average matrix of technical coefficients, mathematical tools which help the user make the I-O model, and tools which allow the user to change data, conduct impact analysis, and generate reports.

Application of IMPLAN to Evaluate EIS Alternatives

Regional economic impacts are concerned with the effects of changes in the economy of a region. The magnitudes of the economic impacts are determined by the interactions between linkages within the local/regional economy and the leakages from this economy to the larger economy. Economic linkages are the relationships between industries, businesses, factors of production (e.g., labor and capital) and government created by trade and other exchange, such as taxes, within and among regions. Economic linkages create multiplier effects in a regional economy as money is circulated by trade. The magnitudes of impacts resulting from economic

linkages are limited by the amount of leakage that occurs within the region. Economic leakages are a measure of the income shares spent outside of the region. Thus, the more the economic leakage, the less the multiplier effect. Economic leakages are generally higher the smaller the regional economy. For example, the economic leakages for a county are larger than those for the state which are larger than those for the nation.

The regional economic impacts identified in EIS Chapter 11, “Agricultural Resources” were evaluated for each alternative. Modeling objectives included the evaluation of the following potential impacts:

- Effects on regional employment
- Effects on regional total economic output

Modeling Assumptions

The primary assumption attributable to IMPLAN concerns linkages among regions. Each of the IMPLAN models is a single-region model. Other than assumptions on imports, exports, and regional purchases, the models do not explicitly recognize inter-regional interdependencies among sectors. It is believed that the regions defined for the IMPLAN models are sufficiently large so that each is relatively self-sufficient as an economic entity.

No incremental changes in agricultural production over the long-term condition (82-year simulation period analyzed in this EIS) among Alternatives 1 and 2 as compared to the No Action Alternative were estimated. Therefore, no IMPLAN analyses were conducted for regional economic impacts associated with the changes in irrigated agriculture production over the long-term condition. For the analyses of dry and critical dry year conditions, the direct inputs from the SWAP model were used as input into the relevant agricultural sector within each of the regions. Table 7-4 shows the crop categories from the SWAP model and the IMPLAN sector to which each of these crop categories was assigned.

Table 7-4. Mapping SWAP Model Results to IMPLAN Sectors

SWAP Definition	IMPLAN Sector
Almonds and Pistachios	Tree nut farming
Alfalfa	All other crop farming
Corn	Grain farming
Cotton	Cotton farming
Cucurbits	Vegetable and melon farming
Dry Beans	Grain farming
Fresh Tomatoes	Vegetable and melon farming
Grain	Grain farming
Onions and Garlic	Vegetable and melon farming
Other Deciduous	Fruit farming
Other Field	Grain farming
Other Truck	Vegetable and melon farming
Pasture	All other crop farming
Potatoes	Vegetable and melon farming
Processing Tomatoes	Vegetable and melon farming
Rice	Grain farming
Safflower	Oilseed farming
Sugar Beet	Sugarcane and sugar beet farming
Subtropical	Fruit farming
Vine	Fruit farming

Model Input Data

The economic data for the IMPLAN model come from the system of national accounts for the United States based on data collected by the U.S. Department of Commerce's Bureau of Economic Analysis, the U.S. Department of Labor's Bureau of Labor Statistics, and other Federal and State government agencies. Data are collected for 440 distinct producing industry sectors of the national economy corresponding to the North American Industry Classification System (NAICS). Industry sectors are classified on the basis of the primary commodity or service produced. Corresponding data sets are also produced for each county in the United States, allowing analyses at the county level and for geographic aggregations such as clusters of contiguous counties, individual states, or groups of states. Initially, MIG Inc., and now the IMPLAN Group LLC provide annual IMPLAN I-O datasets representing the state of the economy for any region. Since these data rely on the release of Federal economic data, the release of the IMPLAN I-O dataset typically lags by a year or two. For this EIS, the 2009 IMPLAN I-O data were used. Data provided for each industry sector include outputs and inputs from other sectors, value added, employment, wages and business taxes paid, imports and exports, final demand by households and government, capital investment, business inventories, marketing margins, and inflation factors (deflators). These data are provided both for the 440 producing sectors at the national level and for the corresponding sectors at the county level. Data on the technological mix of inputs and levels of transactions between producing sectors are taken from detailed input-output tables of the national economy. National and county level data are the basis for IMPLAN calculations of input-output tables and multipliers for local areas.

Regional IMPLAN Model

The regional economic analysis was conducted using results from the agricultural production impact analyses. The incremental impact results, estimated by the SWAP model were input into the regional IMPLAN models as the direct change caused by each of alternative as compared to

the No Action Alternative. The IMPLAN models were then used to estimate the secondary (indirect and induced) regional employment, income, and output.

Study Areas

IMPLAN models of the multi-county regions were used to measure impacts in terms of total changes in employment and economic output. Table 7-5 lists the counties included in the IMPLAN models for the Sacramento Valley and San Joaquin Valley in the Central Valley Bay-Delta Region.

Table 7-5. Categorization of Counties by Regions

Region	Categorization in the IMPLAN Model For SWAP model Output
Central Valley and Bay-Delta Region – Sacramento Valley	Shasta Tehama Glenn Colusa Butte Yuba Nevada Sutter Placer
Central Valley and Bay-Delta Region – San Joaquin Valley	Stanislaus Madera Merced Fresno Tulare Kings Kern

Key:
SWAP = Statewide Agricultural Production Model

IMPLAN models of each regions were used to estimate the secondary employment and income impacts associated with changes in irrigated agricultural production. Each regional model follows county lines and incorporates, to the extent allowed by available data, the distinct sector characteristics of the region modeled.

Model Limitations

One of the major limitations with the I-O methodology is the assumption of fixed proportions: for any good or service; all inputs are combined in fixed proportions that are invariant with the level of output. Hence, there is no substitution among production inputs and no economies of scale are possible. Additionally, each production function incorporates fixed, invariant technology.

I-O methodology does not model price effects that might be important to a region. The methodology also assumes that resources that become unemployed or employed due to a change in final demand have no alternative employment.

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Analytical Tools Technical Appendix
Attachment 1 – Selection of Analytical Tools

Long-Term Plan to Protect Adult Salmon in the Lower Klamath River Environmental Impact Statement

Draft

Selection of Analytical Tools

This attachment to the Analytical Tools Technical Appendix describes available tools to evaluate various physical, biological, and economic resources, and the tools selected for application in this EIS. Analytical tools used to assess resource area impacts were selected based on applicability to the impact analysis, acceptance of use, and availability for use to meet the project schedule.

The action alternatives, to augment lower Klamath River flows during periods of potential *Ichthyophthirius multifiliis* (Ich) infestation, have the potential to cause impacts directly in the lower Klamath River Basin, and indirectly in the Sacramento-San Joaquin River Basins through changes in imports of Central Valley Project (CVP) water from Trinity Reservoir to the Sacramento River Basin.

A technical analysis process was designed to define the timing and magnitude of the lower Klamath River flow augmentation as defined in Chapter 2 of this appendix. The CVP and State Water Project (SWP) systems were then simulated to supply the required augmentation flows from Trinity Lake and to determine any changes in imports to the Sacramento and San Joaquin River basins and resulting system re-operation. When the water operations were finalized, subsequent analyses of water supply, temperature, fisheries, hydropower, and economics were performed to support the impact analysis required in the EIS.

Many of the available analytical tools identified for potential use in this EIS have been developed for use in a single basin, either the Klamath River basin (including the Trinity River) or the Sacramento and San Joaquin River basins, requiring a separate selection process for different analytical tools in each of the basins. The Trinity Reservoir, Trinity River downstream to Lewiston Reservoir and the Lewiston Reservoir are operationally included in both basins with the import of water from the Trinity to the Sacramento basins. The CalSim II and Trinity-Sacramento HEC-5Q Water Quality models both include the Trinity Reservoir, Trinity River downstream to the Lewiston Reservoir and the Lewiston Reservoir as well as the Sacramento – San Joaquin River basins. To accommodate this the geographic regions are defined as:

- **Klamath River Basin**, including Trinity River Downstream from Lewiston Dam – Includes the Klamath River and the Trinity River from Lewiston Reservoir to the confluence with the Klamath River.

- **Sacramento River, Sacramento-San Joaquin River Delta (Delta) and CVP Facilities and Service Areas** Includes the CVP and SWP affected waterways, including the Sacramento, Feather, and American Rivers, and the Delta.

Water Operations

Since the action alternatives affect the timing and quantity of Trinity import to the Sacramento River basin, there is a potential for impacts to CVP facilities and service areas, including the Delta. Water operations tools considered and selected for the Klamath River Basin and CVP facilities and service areas are discussed below.

Klamath River Basin, including Trinity River Downstream from Lewiston Dam

Klamath Basin Economic and Hydrology Model

The Klamath Basin Economic and Hydrology Model (KB_HEM) estimates changes in on-farm agriculture production on Klamath Project lands that result from changes to agricultural inputs such as water availability and the cost of power. The current application of the model uses previously developed with and without project hydrology developed by Reclamation and does not simulate water operations.

Klamath Project Planning Model

The Klamath Project Planning Model (KPPM) was developed jointly by Reclamation, the National Marine Fisheries Service (NMFS), and the U.S. Fish and Wildlife Service (USFWS) specifically for Endangered Species Act (ESA) consultation on the Klamath Project. It is based on the Water Resources Integrated Modeling System (WRIMS), the same platform used in the CalSim II and CalSim 3.0 models. This water resources system planning model simulates deliveries to the Klamath Project from the Upper Klamath Lake, Clear Lake and Gerber Lake. The model includes the reach of the Klamath River upstream of Iron Gate Dam to Klamath Lake and does not include the project area in the lower Klamath River.

Selected Tool – None Selected, Interpretation/Extrapolation from Available Data or Previous Studies

The action alternatives will have no impact on Klamath River operations or flows upstream from the confluence with the Trinity River. Neither of the existing tools include the lower Klamath River. As the action alternatives do not require modified operations of Reclamation's Klamath Project, PacifiCorp Klamath Project or other facilities on the Klamath River above confluence with the Trinity River, operational modeling for these facilities is not required. Accordingly, no Klamath Basin operations tool was selected.

Sacramento River, Delta and CVP Facilities and Service Areas

This section describes the analytical tools available to simulate and evaluate water operations in the Sacramento River Basin, San Joaquin River Basin, the Delta, and the CVP facilities and Service Areas, including the Trinity River Division facilities.

CalSim II

CalSim II is a specific application of WRIMS to simulate Central Valley water operations. The CalSim II model simulates the operations of the CVP and SWP throughout the Trinity River, Sacramento River, the Delta and the San Joaquin River over an historical range of hydrologic conditions. CalSim II provides outputs for reservoir storage, river flows, diversions, Delta flows and exports, and deliveries to project and non-project users. There are also predefined linkages (i.e., output is used in other models) from the CalSim II model to the temperature, fisheries, hydropower, and economic models anticipated for use in this analysis.

CalLite

The California Department of Water Resources (DWR) and Reclamation developed CalLite as an interactive screening model for evaluating various Central Valley water management alternatives. CalLite simulates the hydrology of the Central Valley, reservoir operations, delivery allocation decisions, Delta salinity, and habitat-ecosystem flow indices over an 82-year planning period. CalLite maintains the hydrologic, operational and institutional integrity of CalSim; the results obtained from a typical CalLite run (less than10 minute run time) are within 1 percent of a corresponding CalSim run (20 minute run time). The CalLite model does not have predefined connections to the temperature, fisheries, hydropower, and economic models that were anticipated for use in this analysis.

CalSim 3.0

CalSim 3.0 is a disaggregation of the CalSim II schematic, using over 1,000 nodes and dynamically linking to a groundwater model to represent land use-based demands and local hydrology impacts of operations alternatives and potential future climates. Although public release of CalSim 3.0 is anticipated for summer or fall 2016 it is not available in the timeframe required for this analysis.

Selected Tool – CalSim II

The CalSim II model was selected for use in this analysis. The CalSim II model is readily available and widely accepted as an appropriate model for EIS purposes, and has recently been used in several system-wide evaluations including the Coordinated Long-Term Operation of the CVP and SWP EIS (Reclamation 2015), San Joaquin River Restoration Program (SJRRP) Program Environmental Impact Statement/Environmental Impact Report (PEIS/R) (Reclamation and DWR 2012), Upper San Joaquin River Basin Storage Investigation (USJRBSI) EIS (Reclamation 2014a), Shasta Lake Water Resource Investigation (SLWRI) EIS (Reclamation 2014b), and Los Vaqueros Enlargement EIS/EIR (Reclamation 2010). The pre-defined linkages with other, subsequent, models anticipated to be utilized in this EIS process allows efficient performance of the required technical analysis to meet the project schedule.

Reservoir and River Temperature and Water Quality

Multiple tools have been developed to evaluate water temperatures and water quality in both rivers and reservoirs. These tools are described for each basin.

Klamath River Basin

The following section describes the tools available for the Klamath River Basin.

Klamath and Trinity River Resource Management Associates (RMA-2 and RMA-11)

The Klamath and Trinity River Resource Management Associates models (RMA-2 and RMA-11, in combination referred to as RMA 2/11) based models are one-dimensional daily hourly flow and water temperature models that use a heat budget formulation to quantify heat flux at the air-water interface. RMA-2 is a hydrodynamic model that solves the St. Venant equations for dynamic flow conditions. RMA-11 uses output from RMA-2 to determine the fate and transport of heat energy through the stream using a full heat budget approach. Both models use the finite element method to solve governing equations of flow and fate/transport.

The Trinity River RMA-2/11 models use meteorological data, observed streamflow data, and observed water temperatures to simulate flow (velocity and stage) and water temperature conditions in the Trinity River for six years of continuous model simulations (2000 through 2005). Spatial domain for the Trinity River is Lewiston Dam to the Klamath River confluence a distance of 177 kilometers (110 miles) with hourly output available approximately every 100 meters (328 feet). Tributaries water temperatures are represented as daily average values.

The Klamath River RMA-2/11 models use meteorological data, observed streamflow data, and observed water temperatures to simulate flow (velocity and stage) and water temperature conditions in the Klamath River. Currently, 11 years of continuous model simulations 2000-2010 are available. Spatial domain for the Klamath River is Link River Dam to the Klamath River estuary (253 miles or 407 kilometers) with hourly output available approximately every 150 meters (492 feet). Tributaries water temperatures are represented as daily average values.

Klamath and Trinity River Basin Model

The Klamath and Trinity River Basin Models (RBM10) are one-dimensional flow-balance models that assumes flow changes are translated downstream instantaneously. RBM10 uses a simple equilibrium flow model. It utilizes a heat budget formulation to quantify the heat flux at the air-water interface. Heat energy is conveyed through the system based on flow and system geometry.

The Trinity RBM10 model uses meteorological, streamflow, and water temperature data as model inputs to simulate a continuous 34-year time series (1980 to 2013). Spatial domain for the Trinity River is Lewiston Dam to the Klamath River confluence 177 kilometers (110 miles) divided into 31 segments (mean reach length = 5.8 kilometers (3.6 miles), reach lengths range from 1.9 to 9 kilometers (1.2 to 5.6 miles). Tributaries water temperatures are represented as weekly average values. The model for the Trinity River has been recently (April 2016) released to the public.

The Klamath RBM10 model uses meteorological data, observed streamflow data, and observed water temperatures are used as model inputs to simulate a continuous 50-year time series (1961 to 2010). Spatial domain for the Klamath River is Link River Dam to the Klamath Estuary (approximately 407 kilometers [253 miles]) divided into 85 segments (mean reach length = 12.9 kilometers [8 miles]), reach lengths range from 0.8 to 52.5 kilometers (0.5 to 32.6 mi). Reservoirs are represented as vertically and laterally mixed (e.g., no stratification). Tributaries water temperatures are represented as weekly average values.

Klamath Reservoirs Water Quality Model (CE-QUAL-W2)

There are four reservoirs on the Klamath River: Keno, J.C. Boyle, Copco 1, and Iron Gate reservoirs which are currently represented with CE-QUAL-W2. Copco 2 is a small afterbay/forebay for Copco 1 and is not included in the CE-QUAL-W2 model, but is, however, evaluated with the RMA 2/11 models as a slow and deep river reach. CE-QUAL-W2 is a two-dimensional, laterally averaged hydrodynamic and water-quality model. The models use finite difference methods to solve governing equations of flow and fate/transport. All reservoirs are spatially represented with segment lengths on the order of 305 meters (1000 feet) and vertical layer thicknesses between 0.6 to 0.9 meters (2 to 3 feet), and produce hourly output. Models

represent individual reservoirs and are available for 2000 through 2004, and 2006 through 2009 for selected river reaches and reservoirs.

Selected Tool – Klamath and Trinity River RBM10

The Klamath and Trinity River RBM10 models were selected for use in this analysis to assess sub-daily temperature biological metrics (e.g., 7-day average of the daily maximum temperatures) as the tools are within the public domain, include the geographic extent required for the analysis, and are currently being applied by resource agencies within the basin. The RBM10 models operate on a daily time step and simulate mean daily temperatures for the spatial and temporal coverage required. A summary of the RBM10 models is provided in Table 1 below.

Table 1. Summary of Klamath and Trinity River RB10 Temperature Models

Model	Dimension	Spatial	Temporal	Domain	Reservoir	Reservoir Operations	Period	Documented	Public Domain
RBM10 Trinity	1-D	5.8 km	Daily	Lewiston Dam to Klamath River	n/a	n/a	1980-2013	Yes	Yes
RBM10 Klamath	1-D	12.9 km	Daily	Link River Dam to Estuary	Laterally and vertically averaged	n/a	1961-2010	Yes	Yes

Key:
D = Dimensional
km = kilometer
n/a = not applicable

Sacramento River, Delta, and CVP Facilities and Service Areas

Reservoir and river water temperature and water quality models for the Sacramento River, Delta, and CVP Facilities and Service Areas are described below.

Trinity-Sacramento River HEC-5Q Water Quality Model

The Trinity-Sacramento River HEC-5Q Water Quality Model is a HEC-5Q-based (one-dimensional) reservoir and river water quality and temperature model of the Trinity Upper Sacramento River system including Trinity Dam and Reservoir, Trinity River to Lewiston Reservoir, Lewiston Dam and Reservoir, Clear Creek Tunnel, Whiskeytown Dam and Reservoir, Clear Creek below Whiskeytown Dam, Spring Creek Tunnel, Shasta Dam and Reservoir, Keswick Dam and Reservoir, Sacramento River from Keswick to Knights Landing, Red Bluff Diversion Dam, Black Butte Dam, and downstream Stony Creek. The model operates on a 6-hour time step to capture diurnal temperature fluctuations.

Reclamation Monthly Water Temperature Models

The Reclamation monthly water temperature models make up a collection of monthly time-step water temperature models used to simulate water temperatures in the Trinity, Sacramento, Feather, and American River basins for use in the Reclamation Mortality Models (fisheries models described later in this attachment). The monthly time-step of these models provides limited utility for this analysis.

Trinity and Lewiston Reservoir Temperature Models

These models are a WQRRS-based one-dimensional of Trinity Lake and a CE-QUAL-W2-based two-dimensional model of Lewiston Reservoir developed in support of the Trinity River Restoration Program. These models provide water temperatures in Trinity and Lewiston reservoirs.

Selected Tool – Trinity-Sacramento River HEC-5Q Water Quality Model

The Trinity-Sacramento River HEC-5Q Water Quality Model was selected for use in this analysis. This model includes a utility program and procedures to accept monthly operations data from the CalSim II model (the selected operations model), and disaggregate the monthly reservoir operations and stream flows to a daily time step to provide an appropriate level of detail to support subsequent analysis. The model is readily available and widely accepted as an appropriate model for analytical purposes, and has recently been used in several large investigations including the SLWRI, and North of Delta Offstream Storage, and the Coordinated Long-Term Operation of the CVP and SWP EIS (Reclamation 2015). A version of the model with 2030 level of climate change incorporated into the meteorological data has been developed for these projects. The pre-defined linkages with the selected CalSim II operations model and other, subsequent, models anticipated to be utilized in this EIS process, and the incorporation of 2030 level of climate change in the default input data set allows efficient performance of the required technical analysis to meet the project schedule.

Fisheries

Multiple fisheries tools have been developed for the Klamath, Trinity, and Sacramento (including tributaries) River basins, and the Delta.

Klamath River Basin

Klamath Basin fisheries tools include the models described below.

Klamath River Ecosystem Diagnosis and Treatment Model

The Ecosystem Diagnosis and Treatment (EDT) model is habitat-based structured to account for the effects of environmental conditions as salmon follow variable life-history ‘trajectories’ through space and time to complete the life cycle. It is used to predict salmon productivity and capacity as a function of varying ecosystem conditions. This model evaluates the potential effects of changing habitat conditions after reintroducing anadromous fish in the upper Klamath River (upstream from Iron Gate Dam).

Klamath Coho Integrated Modeling Framework

The Klamath Coho Integrated Modeling Framework (IMF) is a life-cycle model that evaluates effects of changing water operations on each life stage of Coho Salmon. It estimates Coho Salmon production based on habitat and environmental conditions including flow and water temperature. Because Coho Salmon abundance has not been adequately monitored (i.e., imprecise population estimates), the model relies on habitat carrying capacity to estimate production potential in the Klamath Basin. The Klamath Coho IMF covers the Klamath River from Iron Gate Dam to the estuary.

Klamath River Stream Salmon Simulator

The Klamath River Stream Salmon Simulator (S3) model is used to predict the effects of water management alternatives on the production of juvenile Chinook Salmon. It contains multiple sub-models reflecting the interaction between the physical and biological processes that affect growth, movement, and survival at any given life stage. The S3 model tracks the cause of mortality (redd scour, habitat limitations, disease) throughout the sub-adult life history over time within the mainstem Klamath River from Keno Dam to the estuary. This model was being updated, with an expected completion date sometime in 2016, and is not available at the time of the EIS development in its updated version.

SALMOD

SALMOD is a salmon production model that simulates population dynamics for freshwater salmonids. This model is used to show how habitat quality and carrying capacity are characterized by the hydraulic and thermal properties of individual mesohabitats. The model tracks a population of spatially distinct cohorts that originate as eggs and grow from one life stage to another as a function of water temperature. SALMOD was developed for the Trinity River for the Trinity River Restoration Program evaluation. It has habitat data from prior to any restoration activities. SALMOD was also developed for the Klamath River to the estuary.

Selected Tool – None Selected, Interpretation/Extrapolation from Available Data or Previous Studies

The action alternatives have no effect on Klamath River flows upstream from the confluence with the Trinity River, as all augmentation flows will be released from Trinity Reservoir. Most of the fisheries models for the Klamath Basin are either incomplete, do not reflect current conditions, or not necessary based on the available input data. Furthermore, none of the available tools were developed to evaluate Ich and are likely not suitable for use as an evaluation of the effectiveness of augmentation flows/temperature reduction on reducing Ich.

The fisheries evaluation will be conducted using results from the RBM10 models, providing the water temperatures and hydraulic conditions in the Klamath and Trinity Rivers, relationship flow-habitat relationship and a desktop (e.g., spreadsheet model) analysis.

Sacramento River, Delta, and CVP Facilities and Service Areas

Fisheries models developed for the Sacramento River, Delta, and CVP facilities are described in this section.

Sacramento River SALMOD

SALMOD, described above, was used to assess the effects of any changes in flows and temperatures in the Sacramento River between Keswick Dam and Red Bluff on habitat quality and quantity and ultimately on juvenile production of all Central Valley runs of Chinook salmon. SALMOD uses inputs from CalSim II and the Trinity-Sacramento River HEC-5Q Model.

Interactive Object-Oriented Simulation Model for Winter-run Chinook Salmon

The Interactive Object-oriented Simulation (IOS) model for winter-run Chinook Salmon is a ‘life-cycle’ model that estimates the long-term response of Sacramento River winter-run Chinook Salmon to changing environmental conditions (e.g., river discharge, water temperature, habitat quality on a reach scale). IOS simulates all life stages of Sacramento River winter-run

Chinook Salmon and models individual daily cohorts of fish through their entire life cycle. It was used for comparing the relative effect of different flow, temperature, and water export scenarios on the winter-run Chinook Salmon population that spawns in the upper reaches of California's Sacramento River, migrates downriver and through the Delta to the Pacific Ocean, and returns to the upper Sacramento River to spawn. The model uses inputs from CalSim II and the Trinity-Sacramento River HEC-5Q Model.

Reclamation Salmon Mortality Model

The Reclamation Salmon Mortality Model is used to assess proportional temperature-exposure mortality of three life stages (pre-spawned eggs, fertilized eggs, and pre-emergent fry) for each run of Chinook Salmon in conjunction with the spawning distribution data in the Trinity, Sacramento, Feather, American, and Stanislaus Rivers. It operates on a daily time-step using a linear interpolation between monthly water temperature model outputs. This model requires water temperature data from the Reclamation Monthly Water Temperature Models which are not proposed for use in this analysis, as well as results from the Trinity-Sacramento River HEC-5Q Model.

Sacramento River Ecological Flows Tool

Sacramento River Ecological Flows Tool (SacEFT) to evaluate the effects of the project on riparian species. SacEFT is a decision support tool emphasizing the trade-offs for key ecosystem targets associated with alternative conveyance, water operations and climate futures in the Sacramento River and San Francisco Delta eco-regions.

Oncorhynchus Bayesian Analysis Model

Oncorhynchus Bayesian Analysis model (OBAN), is used to evaluate the effects of multiple covered activities on winter-run Chinook Salmon survival and population dynamics and viability. OBAN uses stages to characterize the salmon life history and estimates the stage-specific vital rates (e.g., survival) from abundance indices. Environmental factors are incorporated into the modeling framework and the vital rates are estimated with uncertainty using probability models (Bayesian estimation). OBAN, while publicly available, does not necessarily have a large user-base with access to, or working knowledge of, the required software and tools.

NMFS Life Cycle Model

NMFS is developing a Chinook Salmon life cycle model, focusing initially on winter-run Chinook Salmon. This model is not complete yet, nor available for public use.

Delta Passage Model

The Delta Passage Model (DPM) is used to estimate Chinook Salmon survival through the Delta. It is based on an accounting of the migratory pathway and location-specific mortality as Chinook Salmon smolts travel through a simplified network of reaches and junctions in the Delta. It takes into account fish migratory speed and travel time, flow, Delta exports, and predation, and quantifies survival of all four runs of Chinook Salmon in the Delta.

Selected Tools –SALMOD, Winter-run Chinook Salmon Interactive Object-Oriented Simulation Model, and Interpretation/Extrapolation from Available Data or Previous Studies

Two fisheries models, SALMOD and IOS were selected for application for this EIS. SALMOD is the best available tool for predicting project-related outcomes (on a relative, not absolute, basis) for all four runs of Chinook Salmon (steelhead effects can be assumed similar to late fall-run Chinook Salmon) species in the upper Sacramento River. SALMOD input was developed in a coordinated effort between USFWS, CDFW, and Reclamation, and has been peer reviewed. It has been approved for use in several other studies, including the 2008 Biological Assessment on the Continued Long-Term Operations of the CVP and SWP (Reclamation 2008) and resulting 2009 BO and Conference Opinion on the Long-Term Operations of the CVP and SWP (NMFS 2009), the Coordinated Long-Term Operation of the CVP and SWP EIS (Reclamation 2015) and the SLWRI EIS (Reclamation 2014b).

The IOS model is the best life cycle model available at the time of this analysis for the Sacramento River winter-run Chinook Salmon. The IOS model was used to evaluate the effects to winter-run Chinook Salmon for the Coordinated Long-Term Operation of the CVP and SWP EIS (Reclamation 2015).

Both models have pre-defined linkages with the CalSim II operations model and the Trinity-Sacramento River HEC-5Q Model to allow efficient performance of the required technical analysis to meet the project schedule.

Hydropower

This section includes descriptions of analytical tools that assess hydropower.

Klamath River Basin

Selected Tool – None Selected, Interpretation/Extrapolation from Available Data or Previous Studies

The proposed action has no impact on flows in the Klamath River basin upstream from the confluence with the Trinity River. All of the flow augmentation is expected to come from Trinity Reservoir on the Trinity River, with hydropower impacts on the Trinity River included in the Sacramento – San Joaquin River Basin models described in the next section.

Sacramento River, Delta, and CVP Facilities and Service Areas

LTGen

The LTGen Model estimates monthly power generation, capacity, and project use (e.g., pumping plant demand) for each CVP generation or pumping facility for each month of a CalSim II simulation. The model uses simplified factors to separate peak and non-peak generation and project use and provides an estimate of net-revenue based on price forecasts.

SWP_Power

The SWP Power Model computes monthly power generation, capacity, and project use (e.g., pumping plant demand) for each SWP power facility for each month of the CalSim II simulation.

The model uses simplified factors to separate peak and non-peak generation and project use and provides an estimate of net-revenue based on price forecasts.

Selected Tool – LTGen and SWP_Power

Both the LTGen and SWP_Power models were selected for use in this EIS. The models are readily available, widely accepted as an appropriate model for EIS analyses, and have recently been used in several large investigations including the SJRRP PEIS/R, USJRBSI EIS, SLWRI EIS. The models are specifically developed to use pre-defined linkages with the selected CalSim II operations model for efficient performance of the required technical analysis to meet the project schedule.

Delta Hydrodynamics and Salinity

This section includes descriptions of analytical tools that assess Delta hydrodynamics.

Sacramento River, Delta, and CVP Facilities and Service Areas

Delta Simulation Model Version 2

Delta Simulation Model Version 2 (DSM2) is a one-dimensional hydrodynamic and water quality simulation model of the Delta developed by the California Department of Water Resources specifically for the Delta. The DSM2 model operates on a 15-minute time-step in order to capture the tidal influences throughout the system of interconnected channels forming the Delta. The model utilizes CalSim II simulation output to obtain boundary conditions and simulates the operation of internal flow control structures.

The model consists of several linked modules, each with a specific purpose.

- DSM2 Hydro simulates the hydrodynamics, flow direction and magnitude, throughout the interconnected delta channels under tidal influence.
- DSM2 Qual simulates the water quality, or salinity, at all locations in the delta given a hydrodynamic property set from DSM2 Hydro.
- DSM2 PTM simulates fate and transport of a neutrally buoyant particles through space and time given a hydrodynamic property set from DSM2 Hydro.
- DSM2 Fingerprinting simulates the proportion of water from different sources at specific locations in the Delta based on a given hydrodynamic property set from DSM2 Hydro

RMA Bay-Delta Model

The RMA Bay-Delta Model is a two-dimensional hydrodynamic, salinity, and particle tracking model of the Sacramento-San Joaquin River Delta. The model produces output data similar to the DSM2 model but with greater hydraulic resolution at the cost of increased data requirements and execution time.

Selected Tool – DSM2 Hydro and Qual

The DSM2 model modules Hydro and Qual were selected for use in this analysis. The model is readily available and widely accepted as an appropriate model for EIS purposes, and has recently been used in several large investigations including the Coordinated Long-Term Operation of the CVP and SWP EIS (Reclamation 2015), SJRRP PEIS/R (Reclamation and DWR 2012), USJRBSI EIS (Reclamation 2014a), and SLWRI EIS (Reclamation 2014b) and Los Vaqueros Enlargement. The model was specifically developed to use pre-defined linkages with the selected CalSim II operations model for efficient performance of the required technical analysis to meet the project schedule. Use of the other modules is not anticipated but could be easily accommodated if they do become necessary.

Agricultural Economics

Agricultural economics are important, particularly in the Klamath and Sacramento River basins. Analytical tools to evaluate the agricultural economics are included in this section.

Klamath River Basin

Klamath Basin Hydro-economic Model (KB_HEM)

The KB_HEM estimates changes in on-farm agriculture production on Klamath Project lands that result from changes to agricultural inputs such as water availability and the cost of power.

Selected Tool – None Selected, Interpretation/Extrapolation from Available Data or Previous Studies

The proposed action has no impact on flows in the Klamath River basin upstream of the confluence with the Trinity River. All of the flow augmentation comes from Trinity Reservoir on the Trinity River.

Sacramento River, Delta, and CVP Facilities and Service Areas

The following models/tools can be used in the Sacramento River, Delta, and CVP Facilities and Service Areas.

Central Valley Production Model (CVPM)

CVPM projects cropping patterns, land use, and water use in the Central Valley of California by considering land availability, water availability and cost, irrigation technology, market conditions, and production costs. The model considers 26 crops and 22 hydrologic regions covering the Central Valley of California and selects those crops, acreage, water supplies, and irrigation technologies that maximize profit subject to certain constraints including availability of land, water and other legal, physical, and economic limitations on an annual time step.

Statewide Agricultural Production Model

The Statewide Agricultural Production Model (SWAP) model is a regional economic model of irrigated agricultural production that simulates the decisions of agricultural producers in California with changes in water supply conditions to maximize net income. SWAP incorporates CVP and SWP water supplies, other local water supplies, and groundwater. For each SWAP region the model optimizes production by adjusting cropping patterns, water sources and

quantities used, and fallows land when that appears to be the most cost-effective response to water resource changes.

Agricultural Water Pricing Model

Estimates the water transfer cost to agricultural producers through application of a water transfer pricing model and through consideration of conveyance costs to agricultural service areas.

Selected Tool – SWAP

The SWAP model was selected for use in this analysis because it is widely accepted, has been used in numerous other major water resource projects is readily available, has sufficient detail for project analysis, and has defined linkages with other models that were used in this EIS.

Regional Economics

Sacramento River, Delta, and CVP Facilities and Service Areas analytical tools that are used for evaluating regional impacts are described in this section.

Impact Analysis for Planning

IMpact Analysis for PLANning Model (IMPLAN) is an input-output model that predicts changes in industry output, value added, and employment as direct, indirect, and induced economic effects for affected industries within a study area. Common uses for water resources planning include estimates of income and employment effects to local communities with new water project construction expenditures and regional economic effects with changes in agricultural production due to water supply availability.

Selected Tool – IMPLAN

IMPLAN was selected for use in this analysis because it is widely accepted, has been used in numerous other major water resource projects, has sufficient detail for project analysis, and is readily available to help meet the project schedule.

Summary of Selected Tools

Modeling tools used for evaluations in this EIS are as follows:

- **CalSim-II** is a statewide water resource planning tool and is a specific application of the WRIMS to simulate Central Valley water operations. CalSim-II provides information about CVP and SWP operations, including reservoir storages, river and canal flows, and project deliveries. Output from CalSim-II is used as an input to all other models listed below, except IMPLAN.

- **Trinity-Sacramento River HEC-5Q Water Quality Model** is a water temperature model that uses Sacramento River flows and inflows, and Shasta, Trinity, and Whiskeytown reservoir storages from CalSim-II to determine water temperatures in the Trinity River from Trinity Lake to Lewiston and in the Sacramento River between Shasta Lake and Red Bluff.

- **SALMOD, Version 3.8**, uses CalSim-II Sacramento River flows and inflows, and water temperatures from the Trinity-Sacramento River HEC-5Q Model to simulate Chinook salmon mortality and escapement.

- **IOS** uses scenario-specific daily DSM2, CalSim II, and Trinity-Sacramento River HEC-5Q Model data as model input to estimate winter-run Chinook survival at multiple life stages

- **Statewide Agricultural Production Model (SWAP), Version 6**, is an agricultural production and economics model that uses CalSim-II water supply deliveries to agricultural contractors to simulate the decisions of agricultural producers (farmers) in California. The model selects crops, water supplies, and irrigation technology to maximize profit.

- **Delta Simulation Model Version 2 (DSM2), Version 8.0.6**, is a Sacramento-San Joaquin River Delta (Delta) hydrodynamic and water quality model that uses CalSim-II Delta inflows, outflows, and exports to determine Delta water quality and water levels.

- **LongTermGen (LTGen), Version 1.18, and State Water Project Power (SWP_Power), Benchmark Study Team (BST) April 6, 2010**, version, are power generation models for the CVP and the SWP, respectively, that use CalSim-II reservoir storages, releases, and project pumping to determine the energy generation and usage of the CVP and SWP.

- **IMPLAN, Version 3.0.17.2**, is a regional economic model that uses construction cost estimates to simulate the effect of construction-related expenditures on the regional economy in terms of changes in industry output, employment, and income.

Attachment 1 References

NMFS (National Marine Fisheries Service). 2009. Biological Opinion and Conference Opinion on the Long-Term Operations of the Central Valley Project and State Water Project. June.

Reclamation (U.S. Department of the Interior, Bureau of Reclamation). 2008. Biological Assessment on the Continued Long-term Operations of the Central Valley Project and the State Water Project. Appendix F Sacramento-San Joaquin Delta Hydrodynamic and Water Quality Model (DSM2 Model). August.

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____. 2015. Coordinated Long-Term Operation of the Central Valley Project and State Water Project Final Environmental Impact Statement. November.

Reclamation and DWR (U.S. Department of the Interior, Bureau of Reclamation and California Department of Water Resources). 2012. San Joaquin River Restoration Program Final Program Environmental Impact Statement/Report. July.

RECLAMATION

Managing Water in the West

Environmental Impact Statement Biological Resources – Terrestrial Technical Appendix

Long-Term Plan to Protect Adult Salmon in the Lower Klamath River
Draft

October 2016

Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

Special-Status Terrestrial Species

Tables 1-1 and 1-2 list special-status wildlife and plant species that potentially occur within the area of potential effect and could be affected by changes under the action alternatives.

Table 1-1. Special-Status Wildlife Species

Common Name	Scientific Name	Status[1] Federal/State /Other	General Habitat in Area of Potential Effect	Regions with Potential Occurrence	Impact Potential
Trinity bristle snail	*Monadenia infumata setosa*	—/T/—	Riparian and conifer forest habitats in the southern Klamath Mountains; known to occur along the Trinity River in the vicinity of Big Bar.	Klamath River (Trinity River)	Hydrologic changes are not expected to affect known or potential habitat.
Big Bar hesperian snail	*Vespericola pressleyi*	—/—/USFS	Riparian areas and conifer forest habitats with wet microsites; known to occur along the lower Trinity River and tributaries.	Klamath River (Trinity River)	Hydrologic changes are not expected to affect known or potential habitat.
Valley Elderberry Longhorn Beetle	*Desmocerus californicus dimorphus*	T/—/—	Riparian habitats and found only in association with its host plant, blue elderberry (*Sambucus nigra* subsp. *caerulea*).	Sacramento Valley and Delta	Hydrologic changes are not expected to affect known or potential habitat.
Western bumble bee	*Bombus occidentalis*	—/—/SSC, BLM, USFS	Various habitats where flowering trees, shrubs, forbs, or crops are present.	Sacramento Valley and Delta, Klamath River	Hydrologic changes are not expected to affect known or potential habitat.
Foothill yellow-legged frog	*Rana boylii*	—/—/SSC, BLM, USFS	Riverine habitats with rocky or cobble substrates.	Klamath River	Hydrologic changes are not expected to affect known or potential habitat.
Western pond turtle	*Emys marmorata*	—/—/USFS	Riverine, lacustrine, and various other wetland habitats. Uses adjacent upland habitats for nesting.	Sacramento Valley and Delta, Klamath River	Hydrologic changes are not expected to affect known or potential habitat.
Giant garter snake	*Thamnophis gigas*	T/T/—	Marshes, ponds, sloughs, small lakes, low-gradient streams, and agricultural wetlands, including irrigation and drainage canals, rice fields, and adjacent uplands.	Sacramento Valley and Delta	Hydrologic changes are not expected to affect known or potential habitat.
Tule greater white- fronted goose (wintering)	*Anser albifrons elgasi*	—/—/SSC	Breed in western Alaska and winter in the Central Valley where they occur in various wetland, grassland, and agricultural habitats.	Sacramento Valley and Delta	Hydrologic changes are not expected to affect known or potential habitat.

Table 1-1. Special-Status Wildlife Species (contd.)

Common Name	Scientific Name	Status[1] Federal/State /Other	General Habitat in Area of Potential Effect	Regions with Potential Occurrence	Impact Potential
Double-crested cormorant	*Phalacrocorax auritus*	—/—/WL	Riverine, lacustrine, and various other wetland habitats. Widespread distribution but local breeder.	Sacramento Valley and Delta, Klamath River	Hydrologic changes are not expected to affect known or potential habitat.
Least Bittern (nesting)	*Ixobrychus exilis*	—/—/ BCC, SSC	Freshwater and brackish marsh habitats in the Sacramento Valley and Delta.	Sacramento Valley, Delta	Hydrologic changes are not expected to affect known or potential habitat.
Cooper's hawk	*Accipiter cooperii*	—/—/WL	Riparian woodland and forest habitats in the Sacramento Valley and Delta regions. Riparian, hardwood, hardwood-conifer, and conifer habitats in the Klamath River region.	Sacramento Valley and Delta, Klamath River	Hydrologic changes are not expected to affect known or potential habitat.
Sharp-shinned hawk	*Accipiter striatus*	—/—/WL	Riparian woodland and forest habitats in the Sacramento Valley and Delta regions. Riparian, hardwood, hardwood-conifer, and conifer habitats in the Klamath River region.	Sacramento Valley and Delta, Klamath River	Hydrologic changes are not expected to affect known or potential habitat.
Swainson's Hawk	*Buteo swainsoni*	—/T/BCC, BLM	Nests in riparian woodlands and forests, roadside trees, tree rows, isolated trees, woodlots, and trees in farmyards and rural residences. Forages in various grassland and agricultural habitats.	Sacramento Valley and Delta	Hydrologic changes are not expected to affect known or potential habitat.
Bald Eagle	*Haliaeetus leucocephalus*	—/E/BCC, BLM, FP, USFS	Nests within or near large riverine and lacustrine habitats. Also use other wetland, grassland, woodland, and agricultural habitats for foraging and during dispersal/wintering.	Sacramento Valley and Delta, Klamath River	Hydrologic changes are not expected to affect known or potential habitat.
Osprey	*Pandion haliaetus*	—/—/WL	Large riverine and lacustrine, and occasionally other wetland habitats.	Sacramento Valley and Delta, Klamath River	Hydrologic changes are not expected to affect known or potential habitat.
White-faced Ibis (nesting colony)	*Plegadis chihi*	—/—/WL	Freshwater marsh and irrigated/flooded agricultural habitats.	Sacramento Valley	Hydrologic changes are not expected to affect known or potential habitat.

Table 1-1. Special-Status Wildlife Species (contd.)

Common Name	Scientific Name	Status[1] Federal/ State/Other	General Habitat in Area of Potential Effect	Regions with Potential Occurrence	Impact Potential
California Black Rail	*Laterallus jamaicensis coturniculus*	—/T/BCC, BLM, FP	Freshwater and tidal emergent marsh habitats.	Sacramento Valley and Delta	Hydrologic changes are not expected to affect known or potential habitat.
California Ridgeway's Rail	*Rallus longirostris obsoletus*	E/E/FP	Tidal emergent marsh habitats.	Delta	Hydrologic changes are not expected to affect known or potential habitat.
Black Tern	*Childonias niger*	—/—/SSC	Freshwater marsh and irrigated/flooded agricultural habitats.	Sacramento Valley	Hydrologic changes are not expected to affect known or potential habitat.
Greater Sandhill Crane (nesting and wintering)	*Grus canadensis tabida*	—/T/BCC, BLM, FP	Breed in meadow, grassland, and agricultural habitats in northeastern California. Winter in the Sacramento Valley between Butte Sink and the Delta, and occur in wetland, grassland, and agricultural habitats.	Sacramento Valley and Delta	Hydrologic changes are not expected to affect known or potential habitat.
Western Yellow-billed Cuckoo	*Coccyzus americanus occidentalis*	T/E/BCC, USFS	Large tracts of riparian habitat along the Sacramento River and Feather River in the Sacramento Valley. Also thought to potentially occur along the Trinity and Klamath Rivers, though known observations in the North Coast Region are limited to lowland estuarine areas (Eel River bottoms, Smith River Estuary).	Sacramento Valley, Klamath River	Hydrologic changes are not expected to affect known or potential habitat.
Purple martin	*Progne subis*	—/—/SSC	Riparian habitats in the Sacramento Valley and Delta regions. Riparian, hardwood, hardwood-conifer, and conifer habitats in the Klamath River region.	Sacramento Valley and Delta, Klamath River	Hydrologic changes are not expected to affect known or potential habitat.
Bank swallow	*Riparia riparia*	—/T/BLM	Riparian and other lowland habitats with vertical banks, bluffs, and cliffs with fine-textured or sandy soils for nesting.	Sacramento Valley and Delta, Klamath River	Hydrologic changes are not expected to affect known or potential habitat.
Yellow-breasted chat	*Icteria virens*	—/—/SSC	Riparian scrub, woodland, and forest habitats.	Sacramento Valley and Delta, Klamath River	Hydrologic changes are not expected to affect known or potential habitat.

Table 1-1. Special-Status Wildlife Species (contd.)

Common Name	Scientific Name	Status[1] Federal/State/Other	General Habitat in Area of Potential Effect	Regions with Potential Occurrence	Impact Potential
Yellow Warbler	*Dendroica petechia brewsteri*	—/—/BCC, SSC	Riparian scrub and woodland habitats.	Sacramento Valley and Delta, Klamath River	Hydrologic changes are not expected to affect known or potential habitat.
Song sparrow ("Modesto" population)	*Melospiza melodia*	—/—/SSC	Riparian and emergent wetland habitats.	Sacramento Valley and Delta	Hydrologic changes are not expected to affect known or potential habitat.
Tricolored blackbird	*Agelaius tricolor*	—/C/BCC, BLM	Emergent wetland, riparian scrub, grassland, and agricultural habitats.	Sacramento Valley and Delta	Hydrologic changes are not expected to affect known or potential habitat.
Pallid bat	*Antrozous pallidus*	—/—/BLM, SSC, USFS	Riparian, emergent wetland, hardwood, hardwood-conifer, and conifer habitats.	Sacramento Valley and Delta, Klamath River	Hydrologic changes are not expected to affect known or potential habitat.
Townsend's big-eared bat	*Corynorhinus townsendii*	—/C/BLM, USFS	Riparian, emergent wetland, hardwood, hardwood-conifer, and conifer habitats.	Sacramento Valley and Delta, Klamath River	Hydrologic changes are not expected to affect known or potential habitat.
Spotted bat	*Euderma maculatum*	—/—/BLM, SSC	Riparian and emergent wetland habitats.	Sacramento Valley	Hydrologic changes are not expected to affect known or potential habitat.
Western red bat	*Lasiurus blossevillii*	—/—/SSC	Riparian and emergent wetland habitats.	Sacramento Valley and Delta	Hydrologic changes are not expected to affect known or potential habitat.
Long-eared myotis	*Myotis evotis*	—/—/BLM	Riparian, emergent wetland, hardwood, hardwood-conifer, and conifer habitats.	Sacramento Valley and Delta, Klamath River	Hydrologic changes are not expected to affect known or potential habitat.
Fringed myotis	*Myotis thysanodes*	—/—/BLM, USFS	Riparian, emergent wetland, hardwood, hardwood-conifer, and conifer habitats.	Sacramento Valley and Delta, Klamath River	Hydrologic changes are not expected to affect known or potential habitat.
Yuma myotis	*Myotis yumanensis*	—/—/BLM	Riparian, emergent wetland, hardwood, hardwood-conifer, and conifer habitats.	Sacramento Valley and Delta, Klamath River	Hydrologic changes are not expected to affect known or potential habitat.

Table 1-1. Special-Status Wildlife Species (contd.)

Common Name	Scientific Name	Status[1] Federal/State /Other	General Habitat in Area of Potential Effect	Regions with Potential Occurrence	Impact Potential
Ringtail	*Bassariscus astutus*	—/—/FP	Riparian, hardwood, hardwood-conifer, and conifer habitats.	Sacramento Valley and Delta, Klamath River	Hydrologic changes are not expected to affect known or potential habitat.
Pacific marten	*Martes caurina*	—/—/USFS	Hardwood, hardwood-conifer, and conifer habitats.	Klamath River	Hydrologic changes are not expected to affect known or potential habitat.
Pacific marten	*Martes caurina humboldtensis*	—/C/SSC, USFS	Hardwood, hardwood-conifer, and conifer habitats.	Klamath River	Hydrologic changes are not expected to affect known or potential habitat.
Pacific fisher - West Coast DPS	*Pekania pennanti*	—/—/BLM, SSC, USFS	Riparian, hardwood, hardwood-conifer, and conifer habitats.	Klamath River	Hydrologic changes are not expected to affect known or potential habitat.

Notes:
[1] See Status Codes abbreviations.

Key:
Status Codes:
BCC = U.S. Fish and Wildlife Service Bird Species of Conservation Concern
BLM = Bureau of Land Management Sensitive Species
DPS = Distinct Population Segment
C = Candidate for Listing as Threatened or Endangered
E = Endangered
FP = California Department of Fish and Wildlife Fully Protected
SSC = California Department of Fish and Wildlife Species of Special Concern
T = Threatened
USFS = Region 5 U.S. Forest Service Sensitive Species
WL = California Department of Fish and Wildlife Watch List

Table 1-2. Special-Status Plant Species

Common Name	Scientific Name	Status[1] Federal/State/Other	General Habitat in Area of Potential Effect	Regions with Potential Occurrence	Impact Potential
Ferris' milk-vetch	*Astragalus tener* var. *ferrisiae*	—/—/BLM, CRPR 1B.1	Sub-alkaline flats in grassland and seasonal wetland habitats.	Sacramento Valley and Delta	Hydrologic changes are not expected to affect known or potential habitat.
Bristle-stalked sedge	*Carex leptalea*	—/—/CRPR 2B.1	Marsh and swamp habitats.	Klamath River	Hydrologic changes are not expected to affect known or potential habitat.
Soft Bird's-beak	*Chloropyron molle* ssp. *molle*	E/R/CRPR 1B.2	Coastal salt marsh and swamp habitats.	Delta	Hydrologic changes are not expected to affect known or potential habitat.
Bolander's Water Hemlock	*Cicuta maculata* var. *bolanderi*	—/—/CRPR 2B.1	Freshwater or brackish marsh and swamp habitats.	Sacramento Valley and Delta	Hydrologic changes are not expected to affect known or potential habitat.
Suisun Thistle	*Cirsium hydrophilum* var. *hydrophilum*	E/—/CRPR 1B.1	Salt marsh and swamp habitats.	Delta	Hydrologic changes are not expected to affect known or potential habitat.
Woolly rose-mallow	*Hibiscus lasiocarpos* var. *occidentalis*	—/—/CRPR 1B.2	Freshwater marsh and riparian habitats.	Sacramento Valley and Delta	Hydrologic changes are not expected to affect known or potential habitat.
Delta Tule Pea	*Lathyrus jepsonii* var. *jepsonii*	—/—/CRPR 1B.2	Freshwater and brackish marsh and swamp habitats.	Delta	Hydrologic changes are not expected to affect known or potential habitat.
Mason's Lilaeopsis	*Lilaeopsis masonii*	—/R/CRPR 1B.1	Freshwater and brackish marsh and swamp, and riparian scrub habitats.	Delta	Hydrologic changes are not expected to affect known or potential habitat.
Delta mudwort	*Limosella australis*	—/—/CRPR 2B.1	Freshwater and brackish marsh and swamp, and riparian scrub habitats.	Delta	Hydrologic changes are not expected to affect known or potential habitat.
Antioch Dunes evening-primrose	*Oenothera deltoides* ssp. *howellii*	E/E/CRPR 1B.1	Remnant river bluffs and sand dunes in the eastern portion of the Delta (east of Antioch).	Delta	Hydrologic changes are not expected to affect known or potential habitat.
Eel-grass pondweed	*Potamogeton zosteriformis*	—/—/CRPR 2B.2	Lake, stream, pond, and marsh and swamp habitats.	Sacramento Valley and Delta	Hydrologic changes are not expected to affect known or potential habitat.
White beaked-rush	*Rhynchospora alba*	—/—/CRPR 2B.2	Freshwater marsh and swamp habitats.	Klamath River	Hydrologic changes are not expected to affect known or potential habitat.

Table 1-2. Special-Status Plant Species (contd.)

Common Name	Scientific Name	Status[1] Federal/State/Other	General Habitat in Area of Potential Effect	Regions with Potential Occurrence	Impact Potential
Sanford's arrowhead	*Sagittaria sanfordii*	—/—/BLM, CRPR 1B.2	Freshwater marsh and swamp habitats, ponds, ditches.	Sacramento Valley and Delta	Hydrologic changes are not expected to affect known or potential habitat.
Suisun Marsh Aster	*Symphyotrichum lentum*	—/—/CRPR 1B.2	Brackish and freshwater marsh and swamp habitats.	Delta	Hydrologic changes are not expected to affect known or potential habitat.
Brazilian watermeal	*Wolffia brasiliensis*	—/—/CRPR 2B.3	Freshwater marsh and swamp habitats.	Sacramento Valley and Delta	Hydrologic changes are not expected to affect known or potential habitat.

Notes:
[1] See Status Codes abbreviations.

Key:
Abbreviations
Delta = Sacramento-San Joaquin River Delta
Status Codes:
E = Endangered
R = Rare
California Rare Plant Rank (CRPR) Codes:
1B = Plants rare, threatened, or endangered in California and elsewhere
2B = Plants rare, threatened, or endangered in California, but more common elsewhere
CRPR Threat Ranks:
.1 = Seriously threatened in California (over 80 percent of occurrences threatened / high degree and immediacy of threat)
.2 = Moderately threatened in California (20-80 percent occurrences threatened / moderate degree and immediacy of threat)
.3 = Not very threatened in California (less than 20 percent of occurrences threatened / low degree and immediacy of threat or no current threats known)

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RECLAMATION

Managing Water in the West

Environmental Impact Statement Cumulative Effects Technical Appendix

Long-Term Plan to Protect Adult Salmon in the Lower Klamath River
Draft

October 2016

Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

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Abbreviations and Acronyms

BO	Biological Opinion
CDFW	California Department of Fish and Wildlife
CEQA	California Environmental Quality Act
DOI	U.S. Department of the Interior
DWR	California Department of Water Resources
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
FERC	Federal Energy Regulatory Commission
MW	megawatt
NEPA	National Environmental Policy Act
NID	Nevada Irrigation District
NMFS	National Marine Fisheries Service
PG&E	Pacific Gas and Electric
SWP	State Water Project

Chapter 1
Cumulative Effects

This appendix provides an overview of National Environmental Policy Act (NEPA) cumulative effects requirements; the methodology used to identify past, present, and reasonably foreseeable future projects or actions; and a description of the reasonably foreseeable future projects or actions considered as part of the cumulative effects analysis for the Long-Term Plan to Protect Adult Salmon in the Lower Klamath River Environmental Impact Statement (EIS).

NEPA Cumulative Effects Requirements

Cumulative effects impacts on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time (40 Code of Federal Regulations Section 1508.7).

Cumulative Effects Methodology

As described in the *Potential Mechanisms for Change and Analytical Methods* sections in Chapters 4 through 14, the impact analyses for all resource areas are primarily based upon changes in reservoir operations and flows related to the release of augmentation flows under the action alternatives as modeled in CalSim II. For the No Action Alternative and action alternatives, the CalSim II model incorporates past, present, and reasonably foreseeable future actions anticipated to occur by the year 2030, such as the release of full restoration flows under the San Joaquin River Restoration Program. In addition, the CalSim II model incorporates anticipated climate change and sea-level rise for 2030. The CalSim II model also incorporates anticipated demands based on county general plan population projections for 2030. The Analytical Tools Technical Appendix provides additional information about assumptions related to projects, climate change, and sea-level rise reasonably expected to occur by the year 2030 that are included in the CalSim II modeling simulations.

However, not all reasonably foreseeable projects are currently included in the CalSim II modeling simulations. Chapter 2, “Additional Reasonably Foreseeable Future Projects or Actions,” of this appendix presents additional reasonably foreseeable projects that meet the NEPA Council on Environmental Quality guidance on cumulative effects analysis that are not currently included in the CalSim II model simulations. In order to provide a complete cumulative effects analysis, additional screening of reasonably foreseeable projects was developed to provide a complete list of projects to be considered for the *Cumulative Effects Analysis* sections found in Chapters 4 through 14 of the EIS. To determine potential additional reasonable foreseeable projects or actions in the study area for this EIS, relevant public documents prepared by Federal, State, and local governments were reviewed and a preliminary list of actions was

developed. These documents include released EISs, Environmental Assessments, management and land use plans, and other environmental compliance documents (e.g., California Environmental Quality Act (CEQA) documents, Federal Energy Regulatory Commission (FERC) relicensing applications). Actions were then evaluated for inclusion in the cumulative effects analysis based on three criteria that all must be met to be considered reasonably foreseeable:

- The action has an identified project sponsor actively pursuing project development, has completed final NEPA or CEQA compliance documents, as appropriate, and appears to be "reasonably foreseeable" given other considerations such as site suitability, funding, economic viability, and regulatory limitations.
  - For actions being developed through federally authorized feasibility studies, legislation providing for construction authorization of a project is also required.
- Available information defines the action in sufficient detail to allow meaningful analysis.
- The action could affect resources potentially affected by the action alternatives.

The cumulative effects analyses in Chapters 4 through 14 of this EIS provide an evaluation (by resource category) of the cumulative effects based on both the projects, water demands, climate change and sea-level rise included in the CalSim II modeling and the projects and actions identified in Chapter 2 of this appendix. Projects and conditions (e.g., climate change, sea-level rise) included in the CalSim II modeling are evaluated quantitatively in Chapters 4 through 14. Projects included in Chapter 2 of this appendix are evaluated qualitatively in the cumulative effects section of Chapters 4 through 14.

Chapter 2
Additional Reasonably Foreseeable Projects or Actions

The additional reasonably foreseeable projects or actions, beyond those projects and actions incorporated in to the CalSim analyses, are described in this chapter. These projects are located within the Klamath River Basin, and Sacramento and San Joaquin River basins (i.e., generally corresponding to Central Valley Project facilities and service areas).

Additional reasonable foreseeable future projects or actions within the Klamath River Basin are described first and then projects or actions within areas of the Central Valley Project Facilities and Service Areas are described. The projects and actions are organized generally from north to south within those regions, as shown in Figure 2-1.While most projects and actions represented in Figure 2-1 have regional significance, the figure only represents the physical location of these projects or actions.

Table 2-1 is a summary table of the additional reasonably foreseeable projects that are physically within the geographic area affected by the action alternatives and overlap areas or effects within each resource area. The reasonably foreseeable projects are assumed to be implemented by 2030. Chapters 4 through 14 provide the cumulative effects analysis for each resource area.

Note: Project and action physical locations are approximate.

Figure 2-1. Additional Reasonably Foreseeable Projects or Actions

Table 2-1. Additional Reasonably Foreseeable Projects that are Physically Within the Geographic Area Affected by the Action Alternatives and Overlap Areas or Effects Within the Resource Area

Project	Water Supply and Management	Surface Water Quality	Groundwater Resources/ Groundwater Quality	Biological Resources - Fisheries	Biological Resources: Terrestrial	Hydropower Generation	Air Quality, GHG Emissions, and Global Climate Change	Agricultural Resources	Socioeconomics	Indian Trust Assets	Environmental Justice
Klamath River Basin											
Klamath River Main-Stem Dam Removal	X	X		X		X	X		X	X	X
Hoopa Valley Tribe Various Watershed Restoration Projects				X	X				X	X	X
Central Valley Project Facilities and Service Areas											
FERC License Renewal for SWP Oroville Projects	X	X		X		X	X				
FERC Relicensing for Yuba River Watershed Hydroelectric Projects	X			X		X	X				
FERC Merced River and Merced Falls Hydroelectric Projects	X					X	X				

Key:
FERC = Federal Energy Regulatory Commission
GHG = greenhouse gas
SWP = State Water Project

Klamath River Basin

Klamath River Main-Stem Dam Removal

Built between 1903 and 1962, PacifiCorp's Klamath Hydroelectric Project consists of seven hydroelectric developments and one non-generating dam (PacifiCorp 2016). In 2012, the U.S. Department of Interior (DOI) and California Department of Fish and Game (now known as California Department of Fish and Wildlife [CDFW]) released the Klamath Facilities Removal Final EIS/Environmental Impact Report (EIR) that analyzed the potential impacts to the environment from the proposed removal of four PacifiCorp Dams (J.C. Boyle, Copco 1, Copco 2, and Iron Gate, collectively referred to as the Four Facilities) on the Klamath River under the Klamath Hydroelectric Settlement Agreement.

On April 6, 2016, the U.S. Department of the Interior, U.S. Department of Commerce, PacifiCorp, and the states of Oregon and California signed an agreement that, following a process administered by Federal Energy Regulatory Commission (FERC), is expected to remove the Four Facilities on the Klamath River by 2020. The amended dam removal agreement, which uses existing non-Federal funding and follows the same timeline as the original 2010 Klamath Hydroelectric Settlement Agreement, will be filed with FERC for consideration under their established processes. Under the agreement, dam owner PacifiCorp will transfer its license to operate the Klamath River dams to a private company known as the Klamath River Renewal Corporation. This company will oversee the dam removal in 2020. PacifiCorp will continue to operate the dams until they are decommissioned.

State and Federal officials also signed a separate agreement with irrigation interests and other parties known as the 2016 Klamath Power and Facilities Agreement. This agreement is intended to help Klamath Basin irrigators avoid potentially adverse financial and regulatory impacts associated with the return of fish runs to the Upper Klamath Basin, which are anticipated after dams are removed (Reclamation 2016).

Hoopa Valley Tribe Watershed Restoration Projects

There are ongoing tributary enhancement projects to improve fish habitat and identified priority riparian habitat along Mill and Supply Creeks located within the Hoopa Valley Indian Reservation. The channel rehabilitation will result in immediate short-term habitat creation and support long-term natural physical and biological stream processes. This will be accomplished by removing levees and channelization to reconnect the Mill or Supply Creek channels to a restored floodplain, increasing short-term and long-term large wood loading, implementing riparian re-vegetation, and creating off-channel side channels and ponds for Coho Salmon refugia. Through these recovery actions, the quality and quantity of salmonid habitat in Mill and Supply Creeks will increase, helping to increase the populations of Coho Salmon and other salmonids in the Trinity Basin. From a watershed-wide perspective, restoration of the valley floor reach of these tributaries is an opportunity to restore substantial low-gradient winter rearing habitat for both natal and non-natal salmonids in the Trinity Basin. Oversight and project management are provided by Hoopa Tribal Fisheries, National Marine Fisheries Service (NMFS), Trinity Valley Consulting Engineers, and CDFW staff (NMFS 2015).

Central Valley Project Facilities and Service Areas

Federal Energy Regulatory Commission License Renewal for SWP Oroville Projects

The Oroville Facilities, as part of State Water Project (SWP), are operated for flood management, power generation, water quality improvement in the Delta, recreation, and fish and wildlife enhancement. The objective of the relicensing process was to continue operation and maintenance of the Oroville Facilities for electric power generation, along with implementation of any terms and conditions to be considered for inclusion in a new FERC hydroelectric license. The initial FERC license for the Oroville Facilities, issued on February 11, 1957, expired on January 31, 2007. The Final EIR and Final EIS were completed in 2007 (FERC 2007). At this time, the revised Biological Opinion (BO) for U.S. Fish and Wildlife Service has been issued, however the revised BO for NMFS has not been issued. FERC has not yet issued the new 50-year license for the proposed action, and is currently issuing a license annually to California Department of Water Resources (DWR).

Federal Energy Regulatory Commission Relicensing for Yuba River Watershed Hydroelectric Projects

Nevada Irrigation District is applying for a new license for the Yuba-Bear Project (FERC Project No. 2266), and Pacific Gas and Electric (PG&E) are applying for the Drum-Spaulding Project (FERC Project No. 2310). The Yuba-Bear Project is located on the Middle and South Yuba rivers, Bear River, and Jackson and Canyon creeks. Concurrently, PG&E is applying for a license renewal for the Drum-Spaulding Project which is located on the Bear and Yuba rivers. Operations of the two projects are coordinated through multiple facilities and management actions. The Final EIS for these projects was issued in late 2014 (FERC 2014).

Federal Energy Regulatory Commission License Renewal for Merced River and Merced Falls Hydroelectric Projects

The Merced River Hydroelectric Project (FERC No. 2179), and the Merced Falls Hydroelectric Project (FERC No. 2467) are currently in the FERC relicensing process.

On February 26, 2012, Merced Irrigation District filed an application for a new license with FERC for the continued operation and maintenance of its 101.25-megawatt (MW) Merced River Hydroelectric Project. The Merced River Hydroelectric Project is located on the Merced River in Mariposa County and includes both Lake McClure and McSwain Reservoir, two powerhouses (New Exchequer and McSwain), and recreation facilities. The initial FERC license expired on February 28, 2014. The objective of the relicensing process is to continue operation and maintenance of the Merced River Hydroelectric Project facilities for electric power generation, along with implementation of any terms and conditions to be considered for inclusion in a new FERC hydroelectric license (MID 2016).

PG&E filed an application for a new license with FERC for the continued operation and maintenance of its 3.4-MW Merced Falls Hydroelectric Project. The Merced Falls Project is located at RM 55 on the border of Merced and Mariposa Counties, California.

The applications for the two projects are being processed together because they: (1) are located contiguously on the Merced River; (2) the Merced Falls Project's operation depends entirely on

flows released by the upstream Merced River Project; and (3) downstream of the Merced River Project, the environmental effects of both projects are interrelated. The Final EIS for these two projects was released in December 2015 (FERC 2015).

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RECLAMATION

Managing Water in the West

Environmental Impact Statement Statutory Authority Appendix

Long-Term Plan to Protect Adult Salmon in the Lower Klamath River
Draft

October 2016

Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

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Abbreviations and Acronyms

CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
FWCA	Fish and Wildlife Coordination Act
Reauthorization Act of 1995	Trinity River Basin Fish and Wildlife Management Reauthorization Act of 1995
Reclamation	U.S. Department of the Interior, Bureau of Reclamation
ROD	Record of Decision
SWRCB	State Water Resources Control Board
TRD	Trinity River Division
TRD Act	Trinity River Division Act of 1955

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Statutory Authority Appendix

Trinity River Division Act

Construction of the Trinity River Division (TRD) of the Central Valley Project (CVP) was authorized by the Act of August 12, 1955 (Public Law 84-386) (TRD Act). In section 2 of the 1955 TRD Act, Congress directed that the operation of the TRD should be integrated and coordinated with the operation of the CVP, subject to two conditions set forth as distinct Provisos in section 2 of that Act. The first of these two Provisos states that the Secretary of the Interior is authorized and directed to "adopt appropriate measures to insure the preservation and propagation of fish and wildlife" including certain minimum flows in the Trinity River deemed at the time as necessary to maintain the fishery. The second Proviso directs that not less than 50,000 acre-feet of water shall be released and made available to Humboldt County and other downstream users.[1]

The recently released Solicitor's Opinion, M-37030, concludes that each of the two Provisos in section 2 of the TRD Act are "separate and independent limitations on the TRD's integration with, and thus diversion of water to, the CVP" and that the two Provisos may "require separate releases of water as requested by Humboldt County and potentially other downstream users pursuant to Proviso 2 and a 1959 Contract between the U.S. Department of the Interior, Bureau of Reclamation (Reclamation) and Humboldt County."[2] M- Opinion 37030 at 2. Formal opinions of the Solicitor are binding on the Department of the Interior and its bureaus.

Section 2 of the TRD Act and, in particular, Proviso 1 of section 2 was the subject of the recent decision by the District Court for the Eastern District of California in *San Luis Delta Mendota Water Authority v. Jewell*, 52 F. Supp 3d 1020 (E.D. Cal. 2014) regarding the fall flow augmentation in 2013. In that decision, the court concluded that Proviso 1 was limited in scope to the Trinity River basin and did not provide authorization for the Secretary of the Interior to implement the 2013 flow releases to benefit fish in the lower Klamath River. *Id*. at 1063. The court also noted that remand was not appropriate because the focus of Plaintiffs' complaint was the completed 2013 flow releases.[3] The District court did not enter an order enjoining any further releases after 2013, and in 2014 the court did not enjoin flow releases.

---

[1] Reclamation's water permits from the State of California includes the following condition:
"Permittee shall release sufficient water from Trinity and/or Lewiston Reservoirs into the Trinity River so that not less than an annual quantity of 50,000 acre-feet will be available for the beneficial use of Humboldt County and other downstream users."
Condition 9.

[2] The 1959 water delivery contract between Reclamation and Humboldt County includes the following:
"The United States agrees to release sufficient water from Trinity and/or Lewiston Reservoirs into the Trinity River so that not less than an annual quantity of 50,000 acre-feet will be available for the beneficial use of Humboldt County and other downstream users."
Contract, Article 8.

[3] The decision of the district court is currently on appeal to the Ninth Circuit Court of Appeals.

As discussed in more detail in the Solicitor's Opinion, the 1955 TRD Act and its legislative history support the view that the Act authorizes the Proposed Action to augment flows in the lower Klamath River to protect fish migrating through this area to the Trinity River. See M-Opinion 37030 at 9-13. The two Provisos in section 2 of the 1955 TRD Act were included specifically to protect the interests of downstream entities, ensuring that the interests of those downstream from the Project all the way to the ocean would be protected from the impacts of the Project.4 The legislative history specifically shows that, prior to the passage of the 1955 TRD Act, in-basin users became concerned that the construction of the TRD would deprive them of their needs, and they thus sought to ensure that only water that was "surplus" to the needs of the downstream interests in the Trinity and lower Klamath River basins would be exported to the Central Valley.5

In a similar vein, the district court in its decision in *Tehama Colusa Canal Authority v. Interior*, 819 F. Supp 2nd 956 (2011), *aff'd* 721 F.3d 1086 (9th Cir. 2013), held that Congress can expressly provide for in-basin priority of water over the export of that water for general use by the CVP. The court noted that one purpose of the Trinity River division is "to transport Trinity River water to the Sacramento River," but then specifically cited Proviso 2 of the 1955 Act as a limitation on this authority. *Id*. at 982.

The court concluded that the 1955 Act:

> *Demonstrate[s] that Congress knew how to create a preference in the allocation of CVP water for an area when it wanted to do so. The [1955] Act prioritizes 50,000 acre feet of CVP water to Humboldt County. Congress created an express legislative priority for use of CVP water with particularized statutory language applicable to the Trinity River Division Unit.*[6]

Id. This analysis is consistent with the analysis and conclusions in the Solicitor's Opinion, which supports the use of Proviso 2 of section 2 of the TRD Act for the release of water from Trinity Reservoir for beneficial use to Humboldt County and other downstream users below Trinity Reservoir. The use of Trinity Reservoir water for fishery purposes is a beneficial use of water that is consistent with Proviso 2 of Section 2 of the TRD Act, the contract between Reclamation and Humboldt County and the Trinity Division water rights. The Solicitor's Opinion also recommended that Reclamation conduct "an appropriate level of analysis" in response to a request to release Trinity Reservoir water pursuant to Proviso 2 to consider the proposed use of the water and any other requirements or limitations that may apply to such release. There is thus, no absolute requirement that a specific quantity of water must be released in any given year,

---

[4] *See, e.g.* S. Rept. No. 1154, 84th Cong., 1st Sess. (1955), p. 5 ("An asset to the Trinity River Basin, as well as the whole north coastal area, are the fishery resources of the Trinity River. The development of the Trinity River was planned with a view to maintaining and improving fishery conditions.")

[5] The bill reported by the House committee, H.R. 4663, emphasized:

That there is available for importation from the Trinity River, water that is surplus to the present and future water requirements of the Trinity and Klamath River basins, and that surplus water, in the amount proposed in the Trinity River division plan, can be diverted without detrimental effect on fishery resources. House Rept. No. 602, 84th Cong., 1st Sess. At 4 (May 19, 1955).

[6] The court also discussed a similar limitation on the integration of the New Melones Division of the CVP in its authorizing legislation.

rather the quantity and timing is based on the "appropriate level of analysis." Further, the Solicitor's Opinion states "a release made under Proviso 2 may also be part of the long-term management strategy regarding instream flows in the lower Klamath River." M- Opinion 37030 at 15.

The Trinity River Basin Fish and Wildlife Management Reauthorization Act of 1995

The Trinity River Basin Fish and Wildlife Management Reauthorization Act of 1995 (1995 Reauthorization Act), Pub. L No. 104-143, 110 Stat. 1338 (which was enacted after the Central Valley Project Improvement Act (CVPIA) and does not cite that statute) is among the statutes that may also provide authority for the augmentation flow releases.

The district Court in *SLDMWA v. Interior*, suggested that Reclamation could have relied on the 1995 Reauthorization Act as authority to make the augmentation releases. *SLDWMA* at 1061-62. The court also implied that this statute is not limited in the same manner as the court had interpreted the 1955 Act, and instead serves as "an acknowledgement that rehabilitation of fish and wildlife in the Trinity River Basin may require rehabilitation of fish habitat in the lower Klamath River." *Id*.

The 1995 Reauthorization Act modified the Trinity River Basin Fish and Wildlife Management Act of 1984, adding an additional subparagraph to Section 1 of that Act that states:

> *(5) Trinity Basin fisheries restoration is to be measured not only by returning adult anadromous fish spawners, but by the ability of dependent tribal, commercial, and sport fisheries to participate fully, through enhanced in-river and ocean harvest opportunities, in the benefits of restoration.*

The 1995 Act also modified the last subparagraph in Section 1, altering it to include a reference to the aiding ocean populations and the resumption of commercial and recreational fishing activities. The revised subparagraph (7) states:

> *(7) the Secretary requires additional authority to implement a management program, in conjunction with other appropriate agencies, to achieve the long-term goals of restoring fish and wildlife populations in the Trinity River Basin, and, to the extent these restored populations will contribute to ocean populations of adult salmon, steelhead, and other anadromous fish, such management program will aid in the resumption of commercial, including ocean harvest, and recreational fishing activities.*

The 1995 Act also expanded the reach of the authorized fishery restoration activities, amending Section 2(a)(1)(A) so that it states:

> *(a) Subject to subsection (b), the Secretary, in consultation with the Secretary of Commerce where appropriate, shall formulate and implement a fish and wildlife management program for the Trinity River Basin designed to restore the fish and*

> *wildlife populations in such basin to the levels approximating those which existed immediately before the start of the construction referred to in section 1(1) and to maintain such levels. . . . Such program shall include the following activities:*
>
> *(1) The design, construction, operation, and maintenance of facilities to –(A) Rehabilitate fish habitats in the Trinity River between Lewiston Dam and Weitchpec and in the Klamath River downstream of the confluence with the Trinity River.*

Both the House and Senate noted that this change was intended to authorize restoration activity in the Klamath River below the confluence with the Trinity River. S. Rpt. 104-253, 104th Cong. (1996) ("This section authorizes restoration activity in the Klamath River below its confluence with the Trinity River . . ."); H.R. Rpt. 104-395, 104th Cong. (1995) ("Section 3 also authorizes restoration activity in portions of the Klamath River . . .").

The Act also amended section 3 of the 1984 Act to add a new subsection (d), stating:

> *(d) Task Force actions or management on the Klamath River from Weitchpec downstream to the Pacific Ocean shall be coordinated with, and conducted with the full knowledge of, the Klamath River Basin Fisheries Task Force and the Klamath Fishery Management Council, as established under Public Law 99-552. The Secretary shall appoint a designated representative to ensure such coordination and the exchange of information between the Trinity River Task Force and these two entities.*

In addition, the 1995 Act added a section that states:

> *Sec. 5. – Nothing in this Act shall be construed as establishing or affecting any past, present, or future rights of any Indian or Indian tribe or any other individual or entity.*

In the October 1, 2014 Decision and Order, Judge O'Neill suggested that Reclamation could rely on the 1995 Act as authority to make releases to benefit the lower Klamath River, particularly because the addition of language to section 2(a)(1)(A) implied that the Act's focus was broader than just the Trinity River basin.

Section 4 of the 1984 Act, which was amended by the 1995 Act, included an authorization of appropriations for design and construction under the management program to be formulated under section 2 "to remain available until October 1, 1995," and an authorization of appropriations for operations, maintenance, and monitoring under the management program for each of the fiscal years in the 10-year period beginning on October 1, 1985. The 1995 Act extended the authorization in section 4(a) to October 1, 1998, and extended the authorization for operations, maintenance and monitoring for an additional 3 years, or a total of 13 years after the period beginning in 1985.

The 1995 Act also added an additional subsection (i) to section 4 to the 1995 TRD Act, stating:

> *(i) Beginning in the fiscal year immediately following the year the restoration effort is completed and annually thereafter, the Secretary is authorized to seek appropriations as necessary to monitor, evaluate, and maintain program investments and fish and wildlife populations in the Trinity River Basin for the purpose of achieving long-term fish and wildlife restoration goals.*

The program authorization set forth in section 2 is long-term, or permanent, general grant of authority despite the established expiration term for the authorization for appropriations and provides in general authority "[s]uch other activities as the Secretary determines to be necessary to achieve the long-term goal of the program" which include actions to restore habitat in the lower Klamath River such as the proposed fall flow releases.

The Fish and Wildlife Coordination Act

The Fish and Wildlife Coordination Act (FWCA) provides the Secretary with broad authority "to provide assistance to, and cooperate with, Federal, State, and public or private agencies and organizations" to take actions for the "protection, rearing, and stocking of all species of wildlife, resources thereof and their habitat, in controlling losses of the same from disease or other causes." 16 U.S.C. § 661. The Bureau of Reclamation has been delegated authority under the FWCA to take "actions, directly or by providing financial assistance… regarding the construction and/or continued operation and maintenance of any Federal reclamation project" to among other things "improve instream habitat." Departmental Manual, 255 DM 1.

The FWCA provides authority for Reclamation to take actions that result in habitat improvements such as releases of water to improve habitat for the fish in the lower Klamath River below its confluence with the Trinity River. This authority is discretionary. The delegation of authority to Reclamation under the FWCA specifies that any actions taken under this delegation must be related to habitat that is affected by a Reclamation Project. (Reclamation is authorized to conduct activities for the improvement of fish and wildlife habitat associated with water systems or water supplies affected by Reclamation projects, including but not limited to fish passage and screening facilities at any non-Federal water diversion or storage project within the region; Reclamation Manual 6.f.(2) [from 255 DM 1.1.B.)

The action alternatives are authorized by the FWCA because the construction and operation of the Trinity River Division affected the average annual flow in the Trinity River and the Klamath River below its confluence. The flow augmentation improves that habitat.

Central Valley Project Improvement Act

CVPIA§3406(b)(1) provides that the Secretary shall make all reasonable efforts to address "other identified adverse environmental impacts of the CVP not otherwise specifically enumerated in [3406(b)]." Reclamation could conclude that the CVP has adversely impacted

the lower Klamath River. Since the TRD is part of the CVP, this section applies to the Trinity River.

Tribal Trust Obligation

The trust responsibility to protect the tribal fishing rights provides a supplementary authority for the action.

Water Rights

Reclamation holds eight water right permits for the operation of the TRD (Permits 11966, 11967, 11968, 11969, 11970, 11971, 11972, 11973). Three permits (11966, 11970, 11972) are for power generation; the other five allow appropriation of water for multiple purposes, including Fish and Wildlife Enhancement. The current water rights permits for the Trinity Division include terms providing for release of water consistent with Proviso 1 and Proviso 2 of the 1955 Act.

However, the lower Trinity River, and the lower Klamath River below Weitchpec, are not included in the water rights place of use for the five permits mentioned above. The State Water Resources Control Board (SWRCB), in a letter dated August 12, 2012 responding to a temporary urgency change petition filed by Reclamation to add the lower Trinity and Klamath Rivers to the place of use for these permits, stated "As the operator of Trinity Dam, Reclamation may bypass water without a change approval, and may release water for various purposes that do not require State Water Board approval. Examples of these purposes include releases for dam safety or maintenance, releases made to satisfy nonconsumptive cultural resource needs, or releases made to improve instream conditions for the benefit of aquatic resources." However, the SWRCB went on to say that "(A)bsent a transfer or other change approved by the State Water Board, the Division cannot consider the bypass and/or release of water for such purposes as a beneficial use unless Reclamation's permitted place of use includes the streams where the water is bypassed and/or released. If Reclamation is concerned that its Trinity River permits do not cover the place of use for the planned salmonid protection activities, in addition to a Water Code section 1707 Petition, Reclamation should consider filing a Petition for Change of Place of Use pursuant to Water Code section 1701." The SWRCB added "(A) decision to not divert water or failure to put water to beneficial use for a period of five years may result in reversion of the water to the public and result in partial or total revocation of the water right. (Water Code, § 1241.)"

The SWRCB's discussion of the release of water from Trinity Reservoir applies equally to releases made as part of the Trinity River Restoration Program (the so-called "Record of Decision (ROD) Flows"). As part of its ongoing review of Central Valley Project water rights, and as part of a separate action from this Long Term Plan, Reclamation will evaluate whether to petition the SWRCB to protect releases made for the Long-Term Plan to Protect Adult Salmon in the Lower Klamath River, as well as the ROD Flows, from possible revocation and unauthorized diversion, and if so, when to seek such an action from the SWRCB.